PB-216 945

A REPORT ON POLLUTION OF THE UPPER COLORADO RIVER BASIN

Federal Water Pollution Control Administration
Cincinnati, Ohio

April 1969

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

I 67.2:
C71/4

PB 216 945

A REPORT ON

PR - 16

POLLUTION OF THE UPPER COLORADO RIVER BASIN

#16130
0071

Not listed in M.C.
600 ' L.C.

No copy available to send to NTIS

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. Department of Commerce
Springfield VA 22151

UNITED STATES DEPARTMENT OF THE INTERIOR
FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
TECHNICAL ADVISORY AND INVESTIGATIONS BRANCH
CINCINNATI, OHIO
PREPARED IN COOPERATION WITH THE COLORADO RIVER
BASIN WATER QUALITY CONTROL PROJECT
DENVER, COLORADO
APRIL, 1969

82

CONTENTS

	Page No.
SUMMARY AND CONCLUSIONS	1
INTRODUCTION	2
OBJECTIVE	4
STUDY METHODS	4
STUDY RESULTS	5
UPPER COLORADO RIVER MAIN STEM	5
Water Uses	5
Waste Sources	6
Water Quality	6
Dissolved Oxygen	6
Coliform Bacteria	7
Salmonella Bacteria	8
Metals	9
Total Dissolved Solids	9
PRICE RIVER SYSTEM	10
Water Uses	10
Waste Sources	10
Water Quality	11
Dissolved Oxygen	11
Coliform Bacteria	11
Salmonella Bacteria	12
Total Dissolved Solids	12
GUNNISON AND UNCOMPAHGRE RIVER SYSTEM	12
Water Uses	12
Waste Sources	13
Water Quality - Gunnison River	13
Dissolved Oxygen	13
Coliform Bacteria	14
Salmonella Bacteria	14
Metals	14
Total Dissolved Solids	15
Water Quality - North Fork - Gunnison River.	15
Dissolved Oxygen	15
Coliform Bacteria	15
Water Quality - Uncompahgre River	15
Dissolved Oxygen	15
Coliform Bacteria	16
Metals	16
Total Dissolved Solids	16

CONTENTS (Cont.)

	Page No.
SAN JUAN RIVER SYSTEM	17
Water Uses	17
Waste Sources	18
Water Quality - San Juan River	18
Dissolved Oxygen	18
Coliform Bacteria	18
Salmonella Bacteria	18
Metals	19
Total Dissolved Solids	19
Water Quality - Animas River	19
Dissolved Oxygen	19
Coliform Bacteria	19
Salmonella Bacteria	20
Metals	20
Total Dissolved Solids	20
Water Quality - Los Pinos River	20
Water Quality - McElmo Creek	21
Dissolved Oxygen	21
Coliform Bacteria	21
Total Dissolved Solids	21

LIST OF TABLES

Table No.		Follows Page No.
1	COLORADO RIVER - RIFLE, COLO.-MOAB, UTAH Dissolved Oxygen	6
2	" " Coliform Bacteria	7
3	" " Metals	9
4	" " Total Dissolved Solids . .	9
5	PRICE RIVER SYSTEM - Dissolved Oxygen . . .	11
6	" " Coliform Bacteria	11
7	" " Total Dissolved Solids . .	12
8	GUNNISON RIVER SYSTEM - Dissolved Oxygen . .	13
9	" " Coliform Bacteria	14
10	" " Metals	14
11	" " Total Dissolved Solids . .	15
12	NORTH FORK GUNNISON RIVER - Dissolved Oxygen	15
13	" " Coliform Bacteria	15
14	UNCOMPAHGRE RIVER SYSTEM - Dissolved Oxygen	15
15	" " Coliform Bacteria	16
16	" " Metals	16
17	" " Total Dissolved Solids . .	16
18	SAN JUAN RIVER SYSTEM - Dissolved Oxygen . .	18
19	" " Coliform Bacteria	18
20	" " Metals	19
21	" " Total Dissolved Solids . .	19
22	ANIMAS RIVER SYSTEM - Dissolved Oxygen . . .	19
23	" " Coliform Bacteria	19
24	" " Metals	20
25	LOS PINOS RIVER Data Summary	20
26	McELMO CREEK - Dissolved Oxygen	21
27	" " Coliform Bacteria	21

LIST OF FIGURES

Table No.		Follows Page No.
1	Location Map of General Study Area	
2	Location Map of Upper Main Stem - Colorado River Basin	5
3	Location Map of Price River System	10
4	Location Map of Gunnison-Uncompahgre River Basin	12
5	Location Map of San Juan River System . . .	17
6	Location Map of Animas River	19
7	Location Map of McElmo Creek	21

SUMMARY AND CONCLUSIONS

1. Water quality field studies were made on the Upper Colorado River main stem, Price River system, Gunnison-Uncompahgre River systems, and San Juan River system during July and August 1966 to determine levels of dissolved oxygen (DO), coliform bacteria, Salmonella bacteria, metals, and total dissolved solids.

2. DO concentrations were not found to be a serious problem extensively. Minimum DO concentrations were critical downstream from some untreated waste sources. For example, minimum DO's were 3.2 mg/l downstream from Paonia, Colorado, on the North Fork Gunnison River and 3.4 mg/l downstream from Price, Utah, on the Price River. There was significant diurnal variation with supersaturation of DO at many stations on all rivers.

3. Fecal coliform densities greater than the 2,000 MPN/100 ml criterion for recreational waters recommended by the National Technical Advisory Committee on Water Quality Criteria were found in Rifle Creek, near the mouth, downstream from Grand Junction and Fruita, Colorado, in the Upper Colorado River main stem; downstream from Helper and Price, Utah, and in Flood Wash in the Price River system; downstream from Delta and Ouray, Colorado, in the Gunnison-Uncompahgre River system; and downstream from Farmington, New Mexico, and Durango and Cortez, Colorado, in the San Juan system.

4. Pathogenic Salmonella, generally of those species most frequently reported as causes of human infection, were isolated from most stations in which swabs were placed downstream from domestic waste sources.

5. Iron and manganese concentrations were frequently greater than the U. S. Public Health Service Drinking Water Standards. This could increase treatment costs for 15 domestic and 27 industrial water supplies within the study area. The production of aquatic life could be adversely affected by the iron concentrations upstream from Moab, Utah, in the Upper Colorado River main

/

stem, the aluminum, copper, iron, and zinc concentrations in the upstream reaches of the Uncompahgre River system; and the concentrations of copper, manganese, iron, zinc and cyanide in the upstream reaches of the Animas River basin. Many of concentrations found were above toxic levels for aquatic life.

6. In over 500 miles of the river reaches sampled, the total dissolved solids concentrations exceeded 500 mg/l which is the recommended criterion of the U. S. Public Health Service Drinking Water Standards (1962) for water supplies; and which could prove injurious to sensitive crops or even undesirable for irrigation usages according to the National Technical Advisory Committee water quality criteria. These conditions occurred in reaches of major rivers receiving return irrigation flows.

INTRODUCTION

This report is based on field studies conducted by the Field Investigations Branch, Federal Water Pollution Control Administration (FWPCA), Cincinnati, Ohio, during July and August 1966, as requested by, and in cooperation with, the Colorado River Basin Water Quality Control Project, FWPCA, Denver, Colorado.

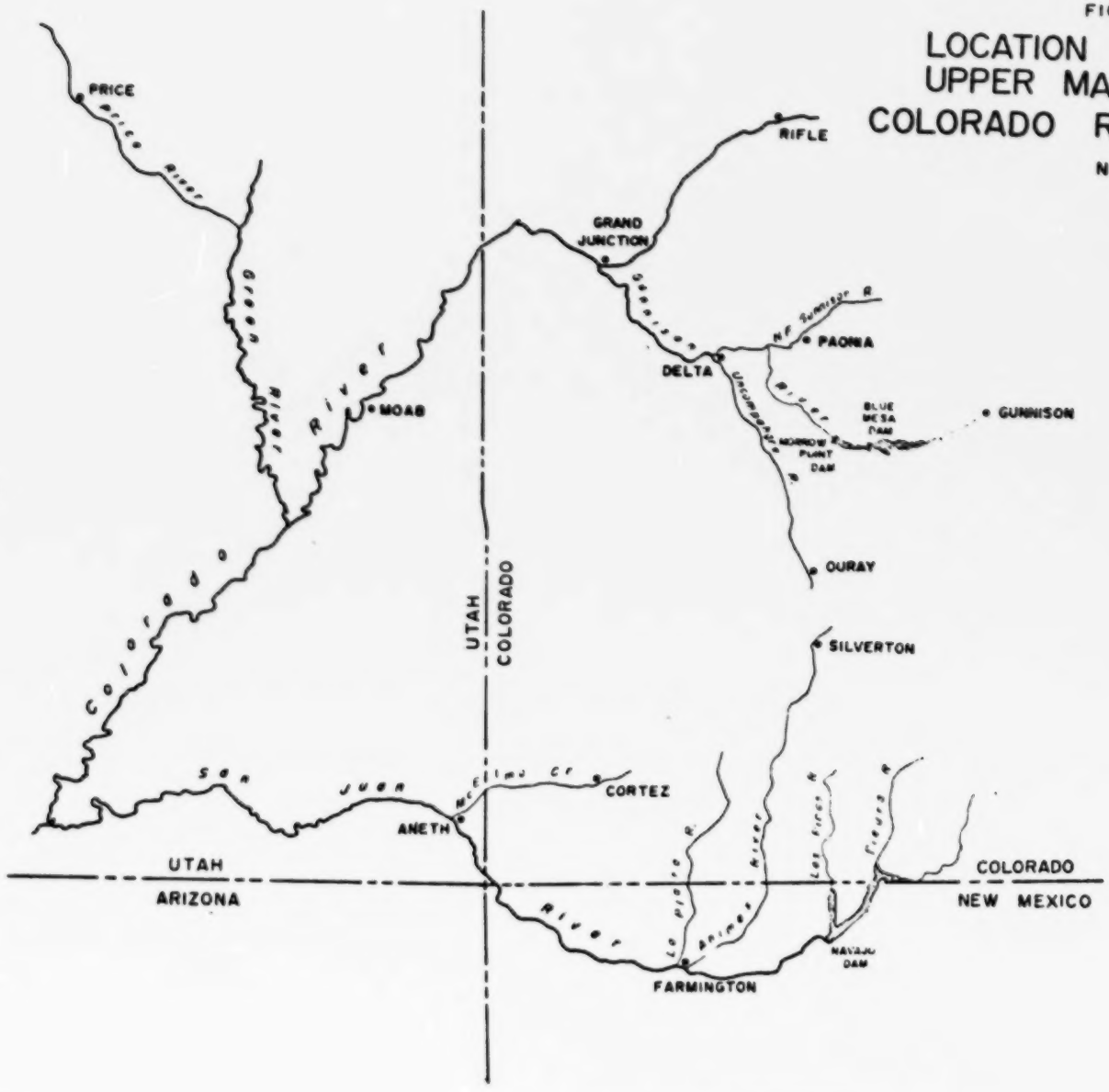
Water quality information is presented here for four geographical areas (Figure 1):

The Upper Colorado River Main Stem
Price River System
Gunnison-Uncompahgre River Systems
The San Juan River System

Water quality characteristics examined were dissolved oxygen, coliform bacteria, Salmonella bacteria, specific conductance, and metals. Water uses considered were public water supply, water contact recreation, fish and aquatic life, and agricultural and industrial water supply. All sampling was conducted within Colorado, New Mexico, and Utah.

FIG 1

LOCATION MAP OF UPPER MAIN STEM COLORADO RIVER BASIN



OBJECTIVE

The study objective was to gather data on water quality to be used as background information for planning and projection by the Colorado River Basin Water Quality Control Project. These studies were not intended to provide detailed information for waste assimilative capacity analyses or similar computations.

STUDY METHODS

The Upper Main Stem Colorado River and Price River were investigated August 17-24, 1966; the Gunnison and Uncompahgre rivers were studied August 1-12, 1966; the San Juan River system was studied July 12-23, 1966. Grab samples were collected for chemical and microbiological analyses from each sampling station during each day of the three surveys. Chemical and bacteriological analyses were performed on site in a mobile laboratory. Samples to be examined for metals and nutrients were preserved and shipped to the base laboratory in Cincinnati, Ohio, for analyses.

Supersaturated DO results from oxygen produced by the photosynthetic process of algae and other aquatic plants. These plants are stimulated and occur in abundance where excess amounts of inorganic nutrients are introduced from waste sources and irrigation return flows. During the night or early morning hours, or during extensive periods of cloudy or inclement weather when photosynthetic production is minimal, dissolved oxygen concentrations can be substantially reduced by respiration of the biotic community.

In streams having wide diurnal variations in DO, minimum, rather than average, concentrations are important. The growth rate of young fish is reduced markedly if the DO concentration falls to 3.0 mg/l for only part of the day, even if it rises to as high as 18 mg/l at other times[1].

To determine the complete range in diurnal DO concentrations, special studies including 24-hour sampling or continuous monitoring would be required. Because personnel and equipment were not sufficient to conduct extensive, round-the-clock sampling in this survey, stream samples were collected during daylight hours only.

---

(1) Anon. 1968. Water Quality Criteria. Report of the National Technical Advisory Committee to the Secretary of the Interior, Federal Water Pollution Control Administration, Washington, D. C.

STUDY RESULTS

UPPER COLORADO RIVER MAIN STEM

Between Rifle, Colorado and Moab, Utah, the Upper Colorado River flows 177 miles in a southwesterly direction through west-central Colorado into southeastern Utah (Figure 2). The drainage area increases from about 6,700 square miles at Rifle to about 29,000 square miles at Moab; the largest tributary within this reach is the Gunnison River with a drainage area of about 7,900 square miles. Other major tributaries include the Green and Dolores rivers.

The long-term average annual flow is 2,700 cfs at Glenwood Springs, Colorado (28 miles upstream from Rifle) and 7,883 cfs at Cisco, Utah (28 miles upstream from Moab), an increase of more than 5,100 cfs within the study reach.

The largest community on this reach of the stream is Grand Junction, Colorado, with a 1960 population of 18,700. Smaller communities and their 1960 populations include Rifle, Colorado, 2,135; Fruita, Colorado, 1,830; and Moab, Utah, 4,680.

Water Uses

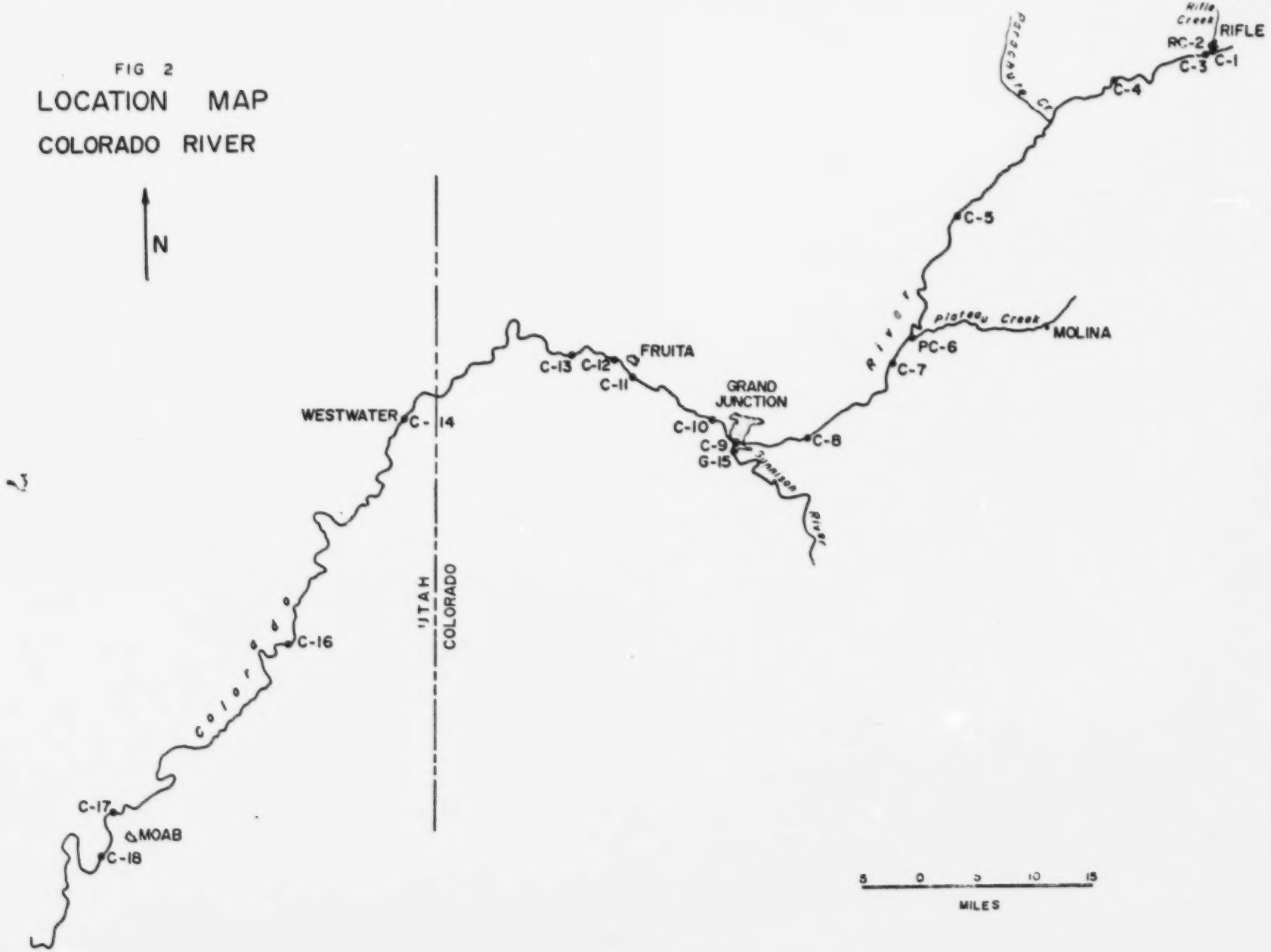
Rifle, Colorado, is the only community within the study reach using the Colorado River as a source of municipal water supply. The Upper Colorado River serves as a source of process and cooling waters for industries, including uranium ore and gilsonite processing, meat packing, canning, and hydroelectric power production.

The Colorado River and its tributaries are used extensively for irritation (Table A-1). Excluding the Gunnison River (considered later in this report), an estimated 215,000 acres were irrigated between Cameo, Colorado and Cisco, Utah, at the time of the survey. Likewise, the Upper Colorado River is used extensively for recreation,

FIG 2

LOCATION MAP

COLORADO RIVER



including fishing, wading, swimming, and picknicking. Trout fishing is exceptionally popular in the Rifle, Colorado area. Because of the shallow water and riffle areas, fishermen wade rather than boat.

Waste Sources

In the drainage area here considered, an estimated 36,550 persons are served by sewage treatment facilities ranging from primary treatment to stabilization ponds and other secondary processes (Table A-2). Estimates of treatment plant efficiencies have been made: the population equivalents* of treated sewage discharged from the total sewered population were 9,650 for biochemical oxygen demand (73.6 percent removed), 8,925 for suspended solids (75.6 percent removed), and 6,919 for coliform bacteria (81.1 percent removed). The principal contributing communities included Grand Junction, Colorado, with an estimated sewered population of 23,000, and Moab, Utah, with an estimated sewered population of 4,200.

Although the quantity and strength of industrial waste discharges are not known, 10 industries contributed to the pollutional load within the study reach (Table A-3). Two of these industries presently have no treatment; seven use lagoons either as total treatment or as a part of the treatment facility.

Institutional wastes from septic tanks and stabilization ponds were discharged from a population of 735 (Table A-4). These wastes had an estimated BOD population equivalent of 177 and a bacterial load of slightly over 100 BPE.

Water Quality

Dissolved Oxygen (DO)

The minimum DO found in the Rifle, Colorado to Parachute Creek reach (Stations C-1 through C-4) was 6.9 mg/l (Table 1). The lowest average DO, which exceeded 7.0 mg/l and 93.5 percent of saturation, occurred at Station C-4. One or more samples containing supersaturated concentrations of DO were collected at each station in the reach.

---

* A population equivalent (PE) is that quantity of the constituent that would be contained in the raw sewage produced by one person per day. A waste containing one population equivalent would contribute one-sixth pound of BOD, one-fifth pound total suspended solids, and 67 billion total coliforms (at the sewer outfall) of which one-third are fecal coliforms.

Table 1

COLORADO RIVER: RIFLE, COLO.-MOAB, UTAH

Dissolved Oxygen

Station Designation	River Mile	Approx. Elev. ft.	Temp. °C.	Spec Cond. µmhos/cm	Total[4] Diss. Solids mg/l	Dissolved Oxygen Max. mg/l	Min. mg/l	Avg. mg/l	Sat. mg/l	% Sat.
C-1	C-1171.7	5250	19	1020	600	9.4	6.2	7.5	7.65	96.0
RC-2	C-1171-6-0.1	5250	17	1520	1060[1]	9.0	8.1	8.5	7.96	106.7[3]
C-3	C-1170.0	5250	19	-	610[1]	9.2	7.2	7.6	7.65	99.3
C-4	C-1160.9	5100	19	1050	620	8.4	7.0	7.3	7.81	93.5
C-5	C-1138.8	4900	20	-	620[1]	7.7	7.2	7.4	7.68	96.3
RC-6	C-1123.3-0.1	4850	21	-	-	8.2	7.9	8.0	7.58[2]	105.5[3]
C-7	C-1119.8	4750	21	1050	620	7.9	7.1	7.5	7.59	98.8
C-8	C-1109.05	4700	21	1250	740	8.3	7.0	7.6	7.62	99.7
C-9	C-1102.8	4600	22	1500	1065	9.3	6.6	7.6	7.48	101.6[3]
C-10	C-1098.0	4500	23	1570	1115	8.5	5.0	6.9	7.37	93.6
C-11	C-1091.1	4450	23	-	1115[1]	11.3	5.2	7.2	7.37	97.7
C-12	C-1085.5	4450	24	-	1300[1]	12.4	5.7	9.1	7.23	125.9[3]
C-13	C-1084.0	4450	21	1900	1350	7.5	5.6	7.0	7.62	91.9
C-14	C-1058.7	4350	23	1900	1320	8.6	6.4	7.8	7.40	105.4[3]
C-16	C-1025.5	3900	22	-	1350[1]	7.9	4.8	6.6	7.64	86.4
C-17	C-995.1	3900	23	1980	1375	6.9	4.2	6.0	7.50	80.0
C-18	C-990.6	3900	23	1970	1370	7.2	6.6	6.8	7.50	90.7

(1) Estimated concentration.
(2) Barometric pressure correction only.
(3) Supersaturation of oxygen.
(4) Calculated from specific conductance by use of factors developed from published USGS water quality data.

Within the reach from Parachute Creek to the Colorado-Utah state line (Stations C-5 through C-13) the minimum observed DO's were 5.0 mg/l at Station C-10 and 5.2 mg/l at Station C-11. Supersaturated DO occurred at least once at every station during the sampling period, and at Stations C-9 and C-12 the DO averages exceeded saturation. Plateau Creek, a tributary stream, received sewage discharges and irrigation return flows, but near its mouth, at Station PC-6, the average DO was 105.5 percent of saturation during the sampling period.

Within the reach from the Colorado-Utah state line to Moab, Utah, (Stations C-14 through C-18), minimum DO's were 4.8 and 4.2 mg/l at Stations C-16 and C-17, respectively. Attached protozoa, indicative of organically enriched water, were present at these stations. Since attached protozoa were not found upstream at Station C-14, the increased oxygen demand, and decreased DO, may have been due to increased respiration of bacteria and other organisms. The Dolores River, a tributary stream, enters the Colorado upstream from Station C-16. This stream was not investigated for its contribution of oxygen-demanding organic matter to the Colorado River.

Within the Upper Colorado River main stem reach, nine of the 16 stations had average DO's with 95 percent of oxygen saturation or greater during sampling. Station C-12, for example, averaged 125 percent saturation.

Coliform Bacteria

Fecal coliforms are those coliform bacteria whose normal habitat is the intestines of man and other warm-blooded animals; they are contained in large numbers in fecal discharges. The presence of fecal coliforms in a stream indicates that domestic sewage or other fecal material has been discharged into the stream. These bacteria may also come from soils, insects, and vegetation that have been in contact with the feces from birds and animals, and which are subsequently washed into streams by irrigation return water or natural runoff. Whatever the source, their sanitary significance is unchanged; fecal coliforms in a stream represent hazardous contamination.

The National Technical Water Quality Advisory Committee has recommended that the average not exceed 2,000 fecal coliforms per 100 ml in surface waters used for general recreational purposes.

This suggested coliform criterion was not exceeded within the Colorado River mainstem reach running from Rifle, Colorado to Parachute Creek (Table 2). The geometric (logarithmic) mean fecal coliform density near the mouth of the tributary Rifle Creek (RC-2) was 2,930 MPN/100 ml and the maximum at this station was 3,300 MPN/100 ml. This small creek flows through Rifle, Colorado,

Table 2

COLORADO RIVER: RIFLE, COLO.-MOAB, UTAH

Coliform Bacteria

Designation	River Mile	Temp °C	Total Coliforms MPN/100 Max.	Total Coliforms MPN/100 Mean	Fecal Coliforms MPN/100 ml Max.	Fecal Coliforms MPN/100 ml Mean	Fecal Coliforms as a % of total Coliforms
C-1	C-1171.7	19	17,000	6,250	2,300	760	12.2
RC-2	C-1171.6-0.1	17	54,000	20,250	3,300	2,930	14.5
C-3	C-1170.0	19	14,000	3,950	3,300	1,020	25.8
C-4	C-1160.9	19	24,000	5,310	1,300	520	9.8
C-5	C-1138.8	20	3,300	2,340	270	< 60	< 2.6
PC-6	C-1123.3-0.1	21	1,400	780	80	40	5.1
C-7	C-1119.8	21	7,000	2,140	330	< 50	< 2.3
C-8	C-1109.05	21	13,000	2,580	130	60	2.3
C-9	C-1102.8	22	79,000	34,700	22,000	5,110	14.7
C-10	C-1098.0	23	3,500,000	586,000	3,500,000	246,000	42.0
C-11	C-1091.1	23	1600,000	135,500	540,000	13,600	10.0
C-12	C-1085.5	24	240,000	51,600	130,000	7,130	13.8
C-13	C-1084.0	21	540,000	83,700	79,000	10,800	12.9
C-14	C-1058.7	23	92,000	27,700	11,000	1,570	5.7
C-16	C-1025.5	22	35,000	4,630	1,300	< 90	< 2.0
C-17	C-995.1	23	11,000	1,080	460	< 30	< 2.8
C-18	C-990.6	23	13,000	3,920	790	< 225	< 5.7

and apparently receives untreated domestic wastes.

The geometric mean fecal coliform density within the reach from Parachute Creek to the Colorado-Utah state line was less than 60 MPN/100 ml in the uppermost three main stem stations, even though treated wastes from approximately 2,400 people directly entered the Colorado River, and treated wastes from 535 people entered from Plateau Creek, a tributary stream.

Beginning at Station C-9 untreated wastes from Grand Junction, Colorado, entered the Colorado River and increased the mean fecal coliform density to 5,110 MPN/100 ml. The next station (C-10) downstream reflects the effect of the Grand Junction sewage treatment plant's discharge. Here the mean fecal coliform density rose to 246,000 MPN/100 ml; or 123 times the Advisory Committee's recommended criterion.

Downstream from Grand Junction to where the river enters Utah, mean fecal coliform densities exceeded 7,000 MPN/100 ml. All mean densities were at least 3.5 times the recommended criterion. Discharges from the sewage treatment plant at Fruita, Colorado, contributed to the high fecal coliform densities.

The mean fecal coliform density at the Colorado-Utah state line was 1,570 MPN/100 ml; the maximum observed density was 11,000 MPN/100 ml. Downstream from this point to Moab, Utah, mean densities were less than 225 MPN/100 ml.

Salmonellae Bacteria

Salmonellae are intestinal pathogenic bacteria which are contained in large numbers in the fecal discharges of infected persons or other warm-blooded animals. Several species within the group cause significant percentages of fatalities in infected persons. Two well known Salmonellae infections are typhoid fever and cholera. Less severe infections of other Salmonellae cause high fevers and gastroenteritis which may cause death in old or weakened persons.

The Communicable Disease Center (CDC) of the U. S. Public Health Service at Atlanta, Georgia, has laboratories for identification of Salmonella sub-species and issues monthly reports of the most common species causing infections in the country (Table 6).

Qualitative sampling for Salmonella to identify species present in streams was accomplished by inserting gauze "swabs" into a stream for five days (Table A-5). Salmonellae were isolated at each station investigated and species were identified by the CDC. Salmonella typhimurium, S. newport, and S. infantis, species among the most frequently reported as causing human infection, were isolated, among others, at stations C-9, C-10, and C-18.

Metals

Analyses were made for seven different metals in the form of total concentrations (unfiltered) (Table 3). At Station C-17 aluminum had a maximum value of 18.5 mg/l and iron, a maximum of 6.6 mg/l. Although biological toxicity was not observed in the river reach, these values exceeded those generally considered acceptable for aquatic life. Iron and manganese concentrations consistently exceeded the recommended Public Health Service Drinking Water Standards. The presence of these metals could increase treatment costs to domestic water users.

Total Dissolved Solids

Return irrigation flows increased the total dissolved solids concentration (TDS) within the 181-mile reach of the upper main stem Colorado River by 228 percent (770 mg/l) (Table 4). The least squares method was used to calculate factors for calculation of TDS concentrations from specific conductance data. These data are published in the water quality records of the U. S. Geological Survey for Colorado and Utah.

Although the Colorado River at Rifle, Colorado, is not classified for public water supply, the community does use the river for this purpose. During the survey period, the 600 mg/l TDS concentration observed upstream from Rifle exceeded the 500 mg/l recommended in the U. S. Public Health Service Drinking Water Standards. The TDS concentrations of approximately 600 mg/l, upstream from the Gunnison River confluence, could be injurious to sensitive crops. The 3.5 sodium adsorption ratio was acceptable. Downstream from the Gunnison River confluence, the added salinity from this tributary reduced the water's value for irrigation by increasing the TDS more than 300 mg/l (from 740 to 1,065 mg/l) and would adversely affect many crops. The TDS concentration increased from about 1,065 to about 1,370 mg/l at Station C-18 at the lower end of the study reach of the upper main stem Colorado River; the sodium adsorption ratio likewise increased from 2.9 to 5.0 to increase the sodium phytotoxicity hazard to plants.

Table 3

COLORADO RIVER: RIFLE, COLO.-MOAB, UTAH

Station Designation	River Mile	Total Sus. Solids mg/l Max.	Total Sus. Solids mg/l Avg.	pH Units	Alk. mg/l $CaCO_3$	Aluminum mg/l Max.	Aluminum mg/l Avg.	Chromium mg/l Max.	Chromium mg/l Avg.	Copper mg/l Max.	Copper mg/l Avg.	Iron mg/l Max.	Iron mg/l Avg.	Manganese mg/l Max.	Manganese mg/l Avg.	Silver mg/l Max.	Silver mg/l Avg.	Zinc mg/l Max.	Zinc mg/l Avg.
C-1	C-11 1..	3	90	8.2	1[illegible]	0.	< 0.5	<0.02	<0.02	0.02	< 0.02	1.0	0.47	0.09	0.0[illegible]	< 0.04	< 0.04	< 0.02	0.02
RC-2	C-11.1.-0.1	[illegible]	[illegible]0	[illegible].[illegible]	2 0	-	-	-	-	-	-	0.1	< 0.1	0.05	< 0.04	-	-	-	-
C-4	C-11 0.9	[illegible]2	41	[illegible].2	1[illegible]	0.	< 0.0	<0.02	<0.02	0.02	< 0.02	1.0	< 0.[illegible]	0.10	0.0[illegible]	< 0.04	< 0.0[illegible]	0.02	< 0.02
C-7	C-1119.8	204	[illegible]3	8.4	1[illegible]	1.0	0.[illegible]	<0.02	<0.02	<0.02	< 0.02	1.9	0.9	0.1[illegible]	0.0[illegible]	< 0.04	< 0.04	0.02	< 0.02
C-9	C-1102.8	21[illegible]	105	[illegible].1	1[illegible]2	< 0.5	< 0.5	<0.02	<0.02	<0.02	< 0.02	1.9	0.9	0.1	0.11	< 0.04	< 0.04	< 0.02	< 0.02
C-10	C-1096.0	238	99	[illegible].1	1[illegible]1	2.[illegible]	< 1.5	<0.02	<0.02	0.02	< 0.02	1.[illegible]	1.0	0.19	0.14	< 0.04	< 0.04	0.0[illegible]	0.0[illegible]
C-13	[illegible]094.0	[illegible]21	259	8.1	1[illegible]0	4.4	2.7	<0.02	<0.02	<0.02	< 0.02	2.0	1.2	0.22	0.14	< 0.04	< 0.04	0.0[illegible]	0.02
C-14	C-10[illegible]3.[illegible]	278	111	[illegible].[illegible]	1[illegible]2	1.[illegible]	1.4	<0.02	<0.02	<0.02	< 0.02	2.[illegible]	1.0	0.19	0.[illegible]6	< 0.04	< 0.0[illegible]	0.02	< 0.02
C-17	C-095.[illegible]	[illegible]110	225	[illegible].[illegible]	1[illegible]8	[illegible]8.[illegible]	0.[illegible]	<0.02	<0.02	0.02	0.02	[illegible].	1.[illegible]	0.[illegible]5	0.11	< 0.04	< 0.0[illegible]	0.10	0.0
C-18	C-090.	[illegible]44	117	[illegible].[illegible]	1[illegible]0	9.3	4.9	<0.02	<0.02	0.02	< 0.02	[illegible].2	1.0	0.20	0.09	< 0.04	< 0.04	0.04	< 0.0[illegible]
Saturation concentration (25°C, pH=[illegible].[illegible])[1]							0.5[illegible]		-		0.0[illegible]		0.0001		0.0[illegible]2		0.00000[illegible][2]		0.[illegible]

(1) Estimated from charts in following reference:

Stumm, W., "Chemistry of Natural Waters in Relation to Water Quality," Symposium on Environmental Measurements, U. S. Department of Health, Education, and Welfare, Publication 999-WP-15, July, 1964.

(2) Calculated on basis of 1.0 mg/l chlorides

Table 4

COLORADO RIVER: RIFLE, COLO.-MOAB, UTAH

Total Dissolved Solids

Designation	River Mile	Sp. Cond. μmhos/cm	Tot. Diss. Solids(1) mg/l	Sodium(1) mg/l	Sodium Adsorption Ratio
C-1	C-1171.7	1020	600	120	3.5
C-4	C-1160.9	1050	620	130	3.6
C-7	C-1119.8	1050	620	130	3.6
C-8	C-1109.05	1250	740	160	4.2
C-9	C-1102.8	1500	1065	140	2.9
C-10	C-1098.0	1570	1115	150	3.0
C-13	C-1084.0	1900	1350	190	3.6
C-14	C-1058.7	1900	1320	240	5.0
C-17	C-995.1	1980	1375	250	5.2
C-18	C-990.6	1970	1370	250	5.2

(1) Calculated from specific conductance by use of factors developed from published USGS water quality data.

PRICE RIVER SYSTEM

Originating in central Utah, the Price River flows in an easterly direction through Schofield Reservoir, northeast to the Colton area, and then in a generally southeasterly direction to join the Green River about 15 miles north of the city of Green River, Utah (Figure 3). Located entirely within Utah, the system drains 1,650 square miles. Tributary streams include the White River, draining approximately 75 square miles, and such lesser tributaries as Willow Creek, Flood Wash, and Icelander Wash. Principal communities, and their 1960 populations in the basin, are Price, 6,800; Helper, 2,460; Wellington, 1,070; and Castle Gate, 320.

Upstream from Helper, the long-term average annual flow is 107 cfs. Downstream from Price, the long-term average annual flow is 95.6 cfs by diversions for irrigation and subsequent loss through evapo-transpiration. Major diversions in this area are by way of the Price and the Carbon canals.

Water Uses

Castle Gate, serving 570 people, is the only community using the Price River as a source of domestic water supply. Principal industrial water users included dry-ice manufacturers, slaughter and meat processors, and coal-washing operators.

Between Helper and Price approximately 96 percent of the average Price River flow was diverted to irrigate approximately 18,000 acres, leaving less than 10 cfs in the main channel during the 1966 survey (Table A-7).

Recreational use of the Price River is limited principally to the Schofield Reservoir reach. Fishing is pursued in upper reaches of the river and for a few miles downstream from the reservoir until tributary runoff carrying fine sediments destroys fish food and decimates fish populations. Flows are insufficient and water quality unsuitable for most recreational pursuits downstream from Price.

Waste Sources

An estimated severed population of 13,900 discharges 10,500 BOD population equivalents (PE) and about 10,000 bacterial PE (Table A-8). The communities of Price and Wellington, combined population 7,800, had no treatment and discharged raw sewage to

FIG. 3
LOCATION MAP
PRICE RIVER

the river. Dragerton, discharging to Icelander Wash, had secondary treatment with chlorination; other communities had primary treatment only.

Two plants, producing dry ice and meat-meal, respectively, discharged untreated wastes to the river (Table A-9). Other industries along the watercourse were connected to municipal sewerage systems, had septic tanks, or used lagoons prior to discharge.

Water Quality

Dissolved Oxygen

DO concentrations averaged greater than 5.4 mg/l at all stations (Table 5). The lowest DO of 3.4 mg/l occurred at Station P-25, located downstream from the Price raw sewage discharge. A significant diurnal variation at this station reflected the effects of attached bottom growths and sludge deposits.

Upstream from Price, between Stations P-23 and P-24, most of the river flow was diverted for irrigation. Return flows degraded the water quality significantly, increasing the TDS nearly sevenfold and decreasing the minimum observed DO by one part per million. The maximum DO of 9.5 mg/l (100 percent saturation) and the minimum of 5.6 mg/l, found at Station P-24, confirmed the effects of algal growths and indicated potential DO decreases when the algae die.

Coliform Bacteria

Domestic waste discharges from Helper, Utah, increased the mean fecal coliform densities from 270 MPN/100 ml at Station P-22, to 6,340 MPN/100 ml at Station P-23 (Table 6). Upstream from Helper, the geometric mean fecal coliform densities were less than 600 MPN/100 ml.

Raw sewage discharged from Price contributed 6,800 bacterial PE, or over 70 percent of the PE discharged to the Price River system (Table A-8), and severely increased the coliform densities.

At Station P-25, one-half mile downstream from the Price sewage outfalls, the geometric mean fecal coliform density was 419,000 MPN/100 ml with a maximum of 790,000 MPN/100 ml; the mean density was 210 times that recommended by the National Technical Advisory Committee on Water Quality Criteria for recreational waters.

Flood Wash, a tributary receiving untreated domestic waste, had a coliform density of 4,480 MPN/100 ml upstream from the Mariana Air Products Company. Downstream from this industry the fecal coliform density was reduced to 730, which indicated that the industrial wastes were toxic to bacteria. These toxic properties were carried into the Price River to Station P-29, where the mean fecal coliform density was only 1,360 MPN/100 ml, even though the station was downstream from the Wellington raw sewage discharge.

Table 5

PRICE RIVER SYSTEM

Dissolved Oxygen

Station Designation	River Mile	Approx. Elev. ft.	Temp. °C.	Spec. Cond. µmhos/cm	Total[1] Diss. Solids mg/l	Dissolved Oxygen Max. mg/l	Min. mg/l	Avg. mg/l	Sat. mg/l	% Sat.	POD, mg/l
P-19	P-106.0	6500	17	330	230	7.8	6.5	7.0	7.76	90.2	
P-20	P-105.4	6500	16	340	240	8.0	6.7	7.1	7.93	89.5	
P-21	P-103.7	6000	16	340	240	8.0	6.6	7.2	8.05	89.4	
WC-21A		6000	13	790	550	9.8	7.0	7.6	8.59	88.5	
P-22	P-102.2	5900	17	350	245	8.4	6.8	7.6	7.90	96.2	2.5
P-23	P-97.1	5700	17	460	320	8.2	6.6	7.4	7.96	93.0	2.9
P-24	P-89.3	5600	16	2250	2020	9.5	5.6	7.6	8.07	94.2	2.2
P-25	P-88.7	5600	17	2240	2020	7.4	3.4	5.4	7.91	68.3	18.7
P-26	P-80.0	5500	19	3870	3490	7.0	5.9	6.2	7.54	82.2	3.8
FW-27	P-78.0-0.7	5500	17	4300	3890	8.8	7.3	7.9	7.83	100.9	2.9
FW-28	P-78.0-0.1	5500	17	4540	4080	8.0	7.5	7.8	7.82	99.6	-
P-29	P-76.6	5500	20	3430	3090	6.8	5.8	6.5	7.34	88.6	3.7
P-31	P-21.2	4700	23	4120	3710	7.5	6.6	6.9	7.16	96.4	2.6
G-32	G-118.2	4200	22	920	640	6.7	5.4	6.3	7.58	83.1	-

(1) Calculated from specific conductance by use of factors developed from published USGS data.

Table 6

PRICE RIVER SYSTEM

Coliform Bacteria

Station Designation	River Mile	Temp °C	Total Coliforms MPN/100 ml Max.	Total Coliforms MPN/100 ml Mean	Fecal Coliforms MPN/100 ml Max.	Fecal Coliforms MPN/100 ml Mean	Fecal Coliforms as a % of Total Coliforms
P-19	P-106.0	17	4,900	1,900	110	< 60	3.2
P-21	P-103.7	16	6,300	2,960	1,300	590	19.9
P-22	P-102.2	17	7,900	2,190	490	270	12.3
P-23	P-97.1	17	240,000	31,200	49,000	6,340	20.3
P-24	P-89.3	16	240,000	58,100	33,000	9,190	15.8
P-25	P-88.7	17	3,300,000	1,765,000	790,000	419,000	23.7
P-26	P-80.0	19	220,000	56,700	22,000	6,620	11.7
FW-27	P-78.0-0.7	17	170,000	82,300	23,000	4,880	5.9
FW-28	P-78.0-0.1	17	160,000	4,860	4,600	730	15.0
P-29	P-76.6	20	92,000	5,670	22,000	1,360	24.0
IW-30	P-39.8-6.3	22	4,900	1,550	80	40	2.6
P-31	P-21.2	23	24,000	4,520	220	85	1.9
G-32	G-118.2	22	1,300	550	40	< 20	3.6

Salmonellae Bacteria

Pathogenic Salmonellae were isolated at all stations investigated; upstream from Castle Gate, downstream from Helper, and downstream from Price (Table A-10). S. heidelberg was isolated downstream from Price and is among those species most frequently reported as a cause of human infection.

Total Dissolved Solids

As mentioned previously, waters upstream from the irrigation diversion contained low TDS concentrations (Table 7). Those downstream from the diversion exceeded 2,000 mg/l, making them undesirable for irrigation. The sodium adsorption ratio from Station P-26 downstream, including the Flood Wash stations, was greater than 8.0, indicating a high sodium phytotoxicity to plants and severely limiting the water value for irrigation use.

From Station P-26 downstream, the osmotic pressure was increased, reaching a maximum of 73.9 milliosmoles, exceeding the 50 milliosmoles recommended by the National Technical Advisory Committee as a maximum for waters supporting well balanced fish and other aquatic life populations.

GUNNISON AND UNCOMPAHGRE RIVER SYSTEM

The Gunnison River and its major tributaries, the North Fork Gunnison and Uncompahgre rivers, flow in a generally northwesterly direction, draining the west-central portion of Colorado (Figure 4). The system drains 7,870 square miles; the North Fork Gunnison and Uncompahgre rivers each drain about 1,100 square miles. Principal Colorado communities and 1960 populations within the basin are Montrose, 5,100; Delta, 3,830; Gunnison 3,480; Ouray, 785; and Paonia, 1,080.

Water Uses

The communities of Montrose, Ouray and Somerset, serving populations of 7,300, use the basin streams as sources of public water supply; Montrose uses the Gunnison River primarily during the winter months; Somerset uses the North Fork Gunnison; Ouray uses Canyon Creek in the Uncompahgre River basin.

Table 7

PRICE RIVER SYSTEM

Total Dissolved Solids

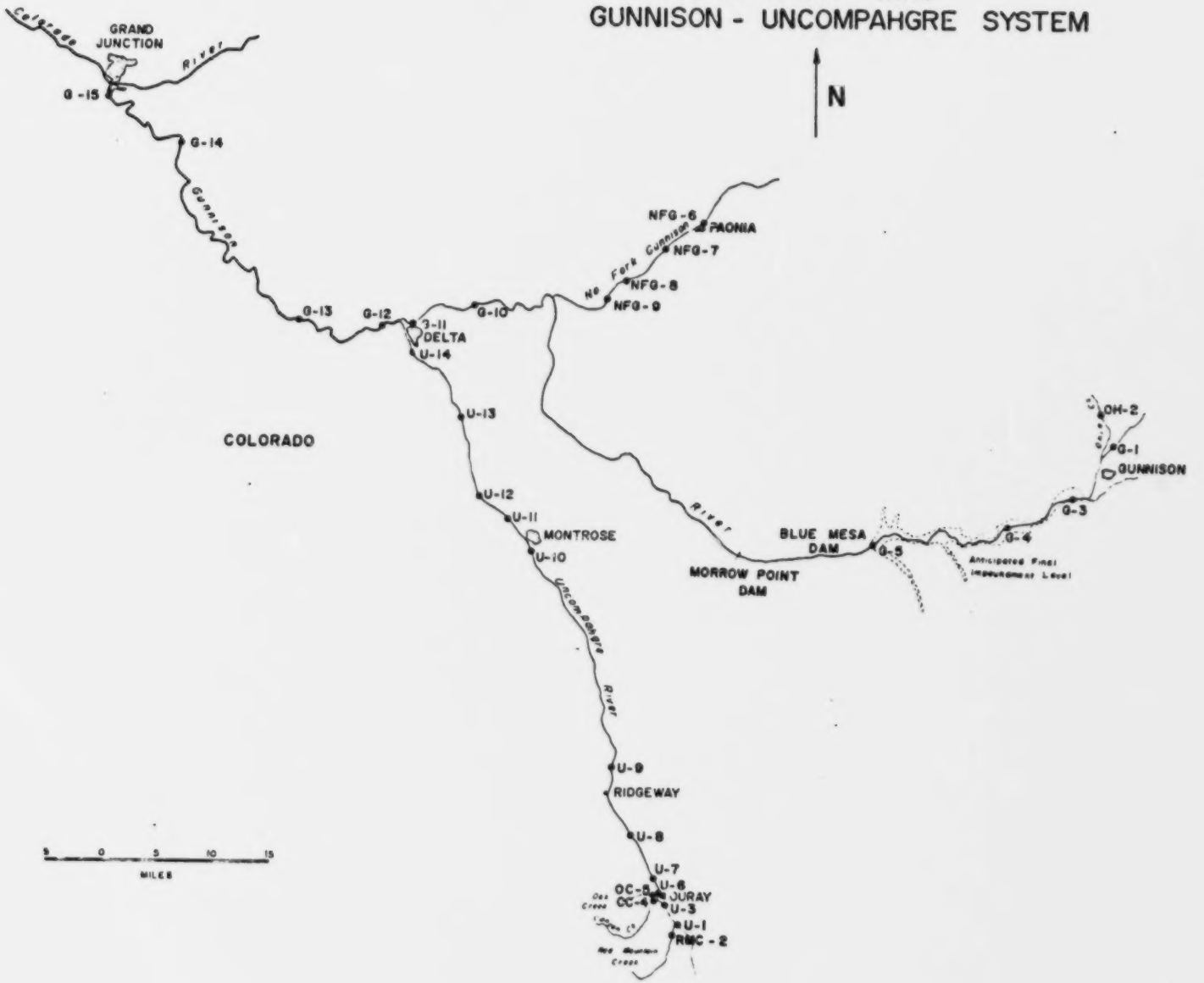
Designation	River Mile	Spec. Conduct. µmhos/cm	Calculated Tot. Diss. Solids mg/l	Sodium mg/l	Sodium Adsorption Ratio	Calculated Osmotic Pressure milliosm.
P-19	P-106.0	330	230(1)	-	-	-
P-20	P-105.4	340	240(1)	-	-	-
P-21	P-103.7	340	240(1)	-	-	-
WC-21A	-	790	550(1)	-	-	-
P-22	P-102.2	350	245(1)	-	-	-
P-23	P-97.1	460	320(1)	-	-	-
P-24	P-89.3	2250	2020(2)	230	4.0	40.3
P-25	P-88.7	2240	2020(2)	230	3.9	40.1
P-26	P-80.0	3870	3490(2)	590	9.9	69.4
FW-27	P-78.0-0.7	4300	3890(2)	680	11.4	77.1
FW-28	P-78.0-0.1	4540	4080(2)	730	12.3	81.3
P-29	P-76.6	3430	3090(2)	490	8.3	61.5
P-31	P-21.2	4120	3710(2)	640	10.8	73.9
G-32	G-118.2	920	640(1)	-	-	-

(1) Calculated from equation: TDS = 0.7 (specific conductance)

(2) Calculated from specific conductance by use of factors developed from data published by the USGS for the Price River near Woodside, Utah

FIG 4

LOCATION MAP
GUNNISON - UNCOMPAHGRE SYSTEM



Primary industrial water uses are hydroelectric power production, cooling water, mineral ore processing, and food processing. Mining operations are centered in the upper Uncompahgre basin. Food processing included principally sugar beet refining and meat packing.

About 233,000 acres are irrigated within the Gunnison-Uncompahgre River basin, 90,000 of which are in the Uncompahgre basin (Table A-11). Large volumes of water, 958 cfs in August 1966, were diverted from the Gunnison River through the Gunnison Tunnel to the Uncompahgre River for irrigation.

Recreation within the basin takes many forms. Trout fishing is popular in the headwaters of all three rivers; boating, swimming, and water skiing are popular in Blue Mesa Reservoir. The scenic beauty of the Gunnison River winding through the colorful Black Canyon is enjoyed by tens of thousands of campers and tourists annually.

Waste Sources

Raw sewage was discharged to the North Fork of the Gunnison River by Hotchkiss and to the Uncompahgre River by Ouray, Ridgeway, and Olathe. Other communities within the basin employed secondary treatment or its equivalent. The combined sewered population of 21,800 discharged an estimated 5,000 PE of BOD and 3,400 bacterial PE's (Table 12).

Holly Sugar Company at Delta, Calloway Packing, Inc. at Colona, and Western Slope Hide and Rendering Company at Montrose discharged untreated wastes to the system (Table A-13). Other industries within the basin employed septic tanks or lagoons for treatment. Among the governmental and institutional waste sources, the Colorado River Storage Project's Power Operation Center, on the Uncompahgre River, had no waste treatment facilities (Table A-14). Other installations employed septic tanks with underground disposal.

Water Quality - Gunnison River

Dissolved Oxygen

Minimum DO's observed during the investigation were greater than 4.0 mg/l at all stations (Table 8). The lowest minimum, 4.4 mg/l, occurred in the Gunnison River at Station G-14 downstream from the entrance of the Uncompahgre and waste discharges from Delta,

Table 8

GUNNISON RIVER SYSTEM

Dissolved Oxygen

Station Designation	River Mile	Approx. Elev ft.	Temp. °C	Spec. Conduc. µmhos/cm	Tot. (1) Diss. Solids mg/l	Dissolved Oxygen Max. mg/l	Min. mg/l	Avg. mg/l	Sat. mg/l	% Sat.
G-1	G-151.0	7,800	12	195	150	7.7	6.7	7.1	8.23(2)	86.3
OHC-2	G-150-2.5	7,800	14	-	-	7.6	5.4	6.8	7.87(2)	86.4
G-3	G-144.0	7,600	14	240	190	8.0	6.5	7.3	7.98(2)	91.5
G-4	G-138.7	7,500	15	-	-	8.4	6.8	7.5	7.81(2)	97.3
G-5	G-120.2	7,300	15	190	150	8.0	7.0	7.4	7.70(2)	96.1
G-10	G-62.9	5,000	20	845	670	8.4	6.3	7.3	7.66	95.3
G-11	G-56.0	5,000	21	1,420	1,130	8.2	4.8	7.0	7.48	93.6
G-12	G-52.5	5,000	21	1,640	1,310	8.2	5.0	7.1	7.48	94.9
G-13	G-42.0	4,900	22	-	1,320(3)	7.5	5.2	6.9	7.35	93.9
G-14	G-14.8	4,800	24	-	1,320(3)	8.0	4.4	6.4	7.12	89.9
G-15	G-1.5	4,600	24	1,710	1,360	9.0	5.2	7.1	7.20	98.

(1) Calculated from specific conductance by use of factors developed from USGS data.

(2) Barometric correction only.

(3) Estimated.

Colorado. DO in the reach downstream from the Holly Sugar Company plant in Delta would be expected to diminisn during the sugar beet campaign in late fall because of untreated waste discharges.

Supersaturation of DO, caused by the photosynthetic processes of algae, was encountered in at least one sample at all stations downstream from Gunnison, Colorado. During the early morning hours and several days of cloudy inclement weather, algae removed DO from the water through processes of respiration. Diurnal DO fluctuation, creating minimal DO concentrations unfavorable for aquatic life production, could become a problem should waste loads increase or irrigation return flows contain larger nutrient quantities to support denser algal populations.

Coliform bacteria

The geometric mean fecal coliform densities were less than the 2,000 MPN/100 ml National Technical Advisory Committee criterion for recreational waters, with the exception of Station G-12 downstream from Delta at the confluence of the Uncompahgre River with the Gunnison River. Here the mean fecal coliform density was 3,300 MPN/100 ml, with a maximum of 35,000 MPN/100 ml (Table 9). At subsequent stations downstream, natural bacterial die-away decreased the fecal coliform density to levels less than the recommended criterion.

Salmonella Bacteria

Salmonellae were isolated from the gauze swabs placed at Stations G-10 and G-12 on the Gunnison River (Table A-15). Salmonella typhimurium and S. blockley, isolated at both stations, are among those species that are reported frequently as causative agents of human infection.

Metals

Of the several metals for which determinations were made, only iron and manganese were present in concentrations considered excessive for satisfactory domestic and industrial water supply usages (Table 10). At three of six stations at which samples were collected within the Gunnison River system, both iron and manganese concentrations exceeded by twofold or more the National Technical Advisory Committee recommended limits for public water supplies. Increased concentrations of these metals would pose a problem for aquatic life.

Table 9

GUNNISON RIVER SYSTEM

Coliform Bacteria

Designation	River Mile	Temp °C	Total Coliforms MPN/100 ml Max.	Total Coliforms MPN/100 ml Mean	Fecal Coliforms MPN/100 ml Max.	Fecal Coliforms MPN/100 ml Mean	Fecal Coli. as a % of Total Coliforms
G-1	G-151.0	12	680	180	190	20	10.8
OHC-2	G-150-2.5	14	5000	740	1300	140	19.6
G-3	G-144	14	35000	4010	3300	850	21.3
G-4	G-138.7	15	24000	3060	940	350	11.4
G-5	G-120.2	15	5000	2620	4	< 2	-
G-10	G-62.9	20	4900	1200	110	< 40	3.0
G-11	G-56.0	21	35000	11350	3300	320	2.8
G-12	G-52.6	21	92000	25100	35000	3300	13.1
G-13	G-42.0	22	35000	8280	2300	1130	13.6
G-14	G-14.8	24	2300(1)	570(1)	24(1)	10(1)	1.8
G-15	G-1.5	24	7900	1160	130	< 40	< 3.2

(1) MF/100 ml.

Table 10

GUNNISON RIVER SYSTEM

Metals

Station Designation	River Mile	Total Iron mg/l Max.	Avg.	Manganese mg/l Max.	Avg.
G-1	G-151.0	0.20	0.1	0.04	< 0.02
G-3	G-144.0	2.0	< 0.4	0.07	0.05
G-5	G-120.2	0.1	< 0.1	0.04	< 0.03
G-10	G-62.9	0.4	0.3	0.09	0.07
G-11	G-56.0	0.9	0.6	0.12	0.11
G-12	G-52.6	2.0	0.6	0.18	0.11
G-15	G-1.5	0.8	0.4	0.11	0.08

Total Dissolved Solids

The increase in TDS from the headwaters of the Gunnison River to its mouth was ninefold (Table 11). Irrigation return flows to the Gunnison, North Fork Gunnison, and Uncompahgre rivers increased the total dissolved solids substantially at Stations G-10 and G-12 and others downstream. The TDS concentrations could prove detrimental to sensitive crops when the water was used for irrigation. Irrigation water withdrawn in the reach from Delta to the Gunnison's mouth would adversely affect many crops and necessitate careful management practices by irrigators.

The sodium adsorption ratios which were less than four at all stations would not cause sodium phytotoxicity.

Water Quality - North Fork Gunnison River

Dissolved Oxygen

The DO concentrations in the North Fork Gunnison River reflected the extensive irrigational use of the river water with input of nutrients and subsequent growth of algae and photosynthetic release of oxygen (Table 12). Supersaturation of DO occurred at all stations with observed average DO values exceeding supersaturation from Paonia, Colorado, to the mouth. Both upstream and downstream from Paonia, minimum DO's observed were at critical 3.2 and 4.4 mg/l concentrations. Since these concentrations represent daylight sampling only, greater DO fluctuation may occur than was indicated.

Coliform Bacteria

The mean fecal coliform densities were less than the recommended 2,000 MPN/100 ml recreational water criterion, but maximum densities observed did indicate some discharge to the system of untreated domestic wastes from small communities (Table 13).

Water Quality - Uncompahgre River

Dissolved Oxygen

Minimum DO concentrations exceeded 6.0 mg/l at all stations sampled on the Uncompahgre River (Table 14). Downstream from Olathe

Table 11

GUNNISON RIVER SYSTEM

Total Dissolved Solids

Designation	River Mile	Specific Conduct. µmhos/cm.	Tot. Diss. Solids[1] mg/l	Sodium[1] mg/l	Sodium Adsorp. Ratio
G-1	G-151.0	196	160	-	-
G-3	G-144.0	240	190	-	-
G-4	G-138.7	190	150	-	-
G-5	G-120.2	190[2]	150[2]	-	-
G-10	G-62.9	845	670	60	1.4
G-11	G-56.0	1420	1130	110	2.2
G-12	G-52.6	1640	1310	130	2.4
G-13	G-42.0	1660[2]	1320[2]	130[2]	2.5
G-14	G-14.8	1660[2]	1320[2]	130[2]	2.5
G-15	G-1.5	1710	1360	140	2.5

Notes:

(1) Calculated from specific conductance by use of factors developed from USGS data.
(2) Estimated

TABLE 12

NORTH FORK GUNNISON RIVER

Dissolved Oxygen

Station Designation	Station River Mile	Approx. Elev. ft.	Temp. °C	Spec. Conduc. µmnos/cm	Tot. (1) Diss. Solids mg/l	Dissolved Oxygen Max. mg/l	Min. mg/l	Avg. mg/l	Sat. mg/l	% Sat.
NFG-6	NFG-17.9	5,700	18	-	-	10.0	3.2	7.	7.78(2)	97.7
NFG-7	NFG-15.5	5,650	19	-	-	10.1	4.4	8.0	7.65(2)	104.6
NFG-8	NFG-7.7	5,350	20	-	-	10.1	8.2	7.8	7.60	102.6
NFG-9	NFG-4.0	5,150	20	1,870	1,490	10.2	5.0	8.4	7.58	110.8

(1) Calculated from specific conductance by use of factors developed from USGS data.

(2) Barometric pressure correction only.

Table 13

NORTH FORK GUNNISON RIVER

Coliform Bacteria

Station Designation	River Mile	Temp. °C.	Total Coliforms MPN/100 ml Max.	Total Coliforms MPN/100 ml Mean	Fecal Coliforms MPN/100 ml Max.	Fecal Coliforms MPN/100 ml Mean	Fecal Coli. as a % of Total Coliforms
NFG-6	NFG-17.9	18	17,000(1)	2,460(1)	2,000(1)	140(1)	5.9
NFG-7	NFG-15.5	19	35,000	19,300	4,900	< 690	< 3.5
NFG-8	NFG-7.7	20	54,000	6,360	13,000	500	6.9
NFG-9	NFG-4.0	20	24,000	7,470	3,300	770	10.3

(1) MF/100 ml.

Table 14

UNCOMPAHGRE RIVER SYSTEM

Dissolved Oxygen

Station Designation	Station River Mile	Approx. Elev. ft.	Temp °C	Spec. Conduc. µmhos/cm	Tot. (2) Diss. Solids mg/l	Dissolved Oxygen Max. mg/l	Min. mg/l	Avg. mg/l	Sat.(1) mg/l	% Sat.
U-1	U-68.0	8,800	12	200	140	7.4	6.2	6.8	7.77	87.5
RMC-2	U-67.8 - 1.0	9,100	13	810	570	7.2	5.9	6.7	7.51	89.2
U-3	U-65.25	8,400	15	570	400	7.3	6.1	6.8	7.43	91.5
CC-4	U-65.2 - 0.01	8,000	15	270	190	8.3	6.3	7.1	7.55	94.0
OC-5	U-65.1 - 0.01	8,000	15	130	90	7.4	6.2	6.9	7.55	91.4
U-6	U-64.9	7,800	14	375	260	7.6	6.0	6.9	7.78	88.7
U-7	U-61.5	7,700	15	-	-	7.3	6.3	6.9	7.78	89.8
U-8	U-56.8	7,000	15	-	-			6.8	7.84	86.7
U-9	U-51.5	7,000	15	840	525	7.7	6.5	7.1	7.84	90.6
U-10	U-29.0	5,900	18	-	-			7.2	7.73	93.1
U-11	U-23.2	5,600	18	-	-	7.9	6.5	7.2	7.81	92.2
U-12	U-12.4	5,300	21	-	-	8.0	6.8	7.4	7.45	99.3
U-13	U-11.0	5,300	26	-	-	12.8	9.3	10.7	6.80	157.4
U-14	U-2.0	5,050	23	1,960	1,610	9.7	7.1	8.7	7.27	119.7

(1) Barometric pressure correction only.

(2) Calculated from specific conductance by use of factors developed from the records of the USGS Station near Delta, Colorado.

and upstream from Delta, Colorado, average DO's were 157 and 120 percent of saturation, respectively. These values are the result of the photosynthetic oxygen production by algae.

Coliform Bacteria

The mean fecal coliform density at all stations sampled was less than the recommended criterion of 2,000 MPN/100 ml, except at Station U-7 downstream from the Ouray waste discharges where the mean density rose to 24,700 MPN/100 ml (Table 15). The mean density at this point was 12 times the recommended criterion. At subsequent stations downstream, natural die-away decreased fecal coliform densities, but the observed maximums remained high. The increased mean density of both total and fecal coliforms within the Uncompahgre River system was caused by waste discharges at various points, as well as irrigation return flows.

Metals

The principal source of metals is the drainage area of Red Mountain Creek. This small drainage basin supplies high concentrations of certain metals from natural oxidation and corrosion of exposed metal sulfides and drainage from both active and abandoned mines (Table 16).

Concentrations of aluminum (15.3 mg/l), copper (0.68 mg/l), iron (16.7 mg/l), and zinc (3.1 mg/l) observed at Station RMC-2 near the mouth of Red Mountain Creek, taken separately or in total, were sufficient to destroy fish and other aquatic life and thus the beneficial use of the stream for fishing. Metal concentrations were above toxic levels for aquatic life in the Uncompahgre River at Station U-3, which is downstream from the Red Mountain Creek confluence.

The Canyon Creek drainage area also yields significant metals concentrations. The input from this area into the Uncompahgre River at Station U-6 in Ouray, Colorado, maintained average concentrations of aluminum at 6.8 mg/l, iron at 4.9 mg/l, and zinc at 0.5 mg/l. These concentrations would be expected to adversely affect aquatic life. Iron and manganese remained a potential problem for water supply uses downstream to the river's mouth.

Total Dissolved Solids

The Uncompahgre River from Ridgeway to confluence with the Gunnison had total dissolved solids concentrations exceeding 1,600 mg/l. These high concentrations make this water an undesirable source of process water for many food processing industries (Table 17). The water's corrosiveness would increase maintenance costs if used for cooling purposes. At these concentrations there would be adverse effects on many crops. Most of the high TDS concentration is attributable to irrigation return waters.

Table 15

UNCOMPAHGRE RIVER SYSTEM

Coliform Bacteria

Designation	River Mile	Temp °C	Total Coliforms MPN/100 ml Max.	Total Coliforms MPN/100 ml Mean	Fecal Coliforms MPN/100 ml Max.	Fecal Coliforms MPN/100 ml Mean	Fecal Coli. as a % of Total Coliforms
U-1	U-68.0	12	170(1)	60(1)	25(1)	< 5(1)	-
RMC-2	U-67.8-1.0	13	20(1)	< 3(1)	4(1)	< 2(1)	-
U-3	U-65.25	15	430(1)	<30(1)	110(1)	< 4(1)	-
CC-4	U-65.2-0.01	15	300(1)	80(1)	46(1)	< 6(1)	-
OC-5	U-65.1-0.01	15	230(1)	160(1)	10(1)	< 3(1)	-
U-6	U-64.9	14	3300	1180	3300	340	29.2
U-7	U-61.5	15	240,000	> 49,100	> 160,000	>24,700	50.3
U-8	U-56.8	15	35,000	6,120	11,000	1,070	17.5
U-9	U-51.5	15	24,000	3,670	3,300	520	14.2
U-10	U-29.0	18	35,000	6,330	1,300	160	2.5
U-11	U-23.2	18	24,000	5,610	1,100	340	6.1
U-12	U-12.4	21	54,000	17,850	2,300	1200	6.7
U-13	U-11.0	26	17,000	3,520	2,300	770	22.0
U-14	U-2.0	23	92,000	13,200	1,300	550	4.2

(1) MF/100 ml

Table 16

UNCOMPAHGRE RIVER SYSTEM

Metals

Station Designation	River Mile	Aluminum mg/l Max.	Aluminum mg/l Avg.	Arsenic mg/l Max.	Arsenic mg/l Avg.	Chromium mg/l Max	Chromium mg/l Avg.	Copper mg/l Max.	Copper mg/l Avg.	Iron mg/l Max.	Iron mg/l Avg.	Manganese mg/l Max.	Manganese mg/l Avg.	Silver mg/l Max.	Silver mg/l Avg.	Zinc mg/l Max.	Zinc mg/l Avg.	Cyanide µg/l Max.	Cyanide µg/l Avg.
U-1	U-68.0	0.5	< 0.5	0.0	0.0	0.02	< 0.02	< 0.02	< 0.02	0.4	0.2	0.19	0.06	< 0.04	< 0.04	0.10	0.10	0.0	0.0
RMC-2	U-67.8-1.0	16.8	15.3	0.024	0.011	0.02	< 0.02	0.84	0.6[illegible]	20.0	16.[illegible]	2.0	1.7	< 0.04	< 0.04	4.[illegible]	[illegible]	0.0	0.0
U-3	U-65.25	7.8	5.7	0.004	0.002	< 0.02	< 0.02	0.30	0.25	6.4	[illegible]	0.94	0.7[illegible]	< 0.04	< 0.04	0.[illegible]	0.[illegible]	2.7	0.5
CC-4	U-65.2-0.01	21.6	< 5.9	-	-	< 0.02	< 0.02	0.03	< 0.02	9.0	2.2	0.86	0.3[illegible]	< 0.04	< 0.04	0.20	0.20	-	-
CC-5	U-65.1-0.01	0.9	< 0.7	-	-	< 0.02	< 0.02	< 0.02	< 0.02	5.0	0.9	0.12	< 0.04	< 0.04	< 0.04	0.03	< 0.02	-	-
U-6	U-64.9	18.0	6.8	0.002	0.001	< 0.02	< 0.02	0.13	0.13	8.4	4.0	1.1	0.[illegible]2	< 0.04	<0.04	0.[illegible]	0.[illegible]4	0.7	0.2
U-9	U-51.5	5.2	< 2.1	0.002	0.002	< 0.02	< 0.02	0.07	< 0.04	3.1	1.4	0.36	0.2[illegible]	< 0.04	< 0.04	0.17	0.14	0.2	0.1[illegible]
U-14	U-2.0	4.0	< 1.4	0.0	0.0	< 0.02	< 0.02	< 0.02	< 0.02	1.5	0.[illegible]	0.1[illegible]	0.10	< 0.04	< 0.04	0.04	< 0.02	-	-

Table 17

UNCOMPAHGRE RIVER SYSTEM

Total Dissolved Solids

Station Designation	River Mile	Spec. Cond. umhos/cm	Tot. Diss. Solids mg/l	Sodium mg/l	Sodium Adsorption Ratio
U-1	U-68.0	205	140(1)	-	-
RMC-2	U-67.8-1.0	810	570(1)	-	-
U-3	U-65.25	570	400(1)	-	-
CC-4	U-65.2-0.01	270	190(1)	-	-
OC-5	U-65.1-0.01	130	90(1)	-	-
U-6	U-64.9	375	260(1)	-	-
U-9	U-51.5	640	525(2)	1(2)	0.02
U-14	U-2.0	1960	1610(2)	155(2)	2.7

(1) estimated on basis of 0.7 times specific conductance

(2) calculated from specific conductance by use of factors developed from the record of the USGS station near Delta, Colorado

SAN JUAN RIVER SYSTEM

Originating at the confluence of the North and South Forks a few miles northeast of Pagosa Springs, Colorado, the San Juan River drains approximately 18,500 square miles in Colorado, New Mexico, and Utah. From its point of origin the river flows southwesterly into the Navajo Reservoir, crosses the Colorado-New Mexico state line to Blanco, New Mexico, and turns westward to Shiprock. From Shiprock the river flows northwesterly back into Colorado, and then into Utah to near Aneth, Utah, which was the end of the study reach (Figure 5). Tributary streams to the San Juan River include the Piedra, Los Pinos, Animas, and La Plata rivers, and McElmo Creek. All are interstate except the Piedra. Principal communities and 1960 populations within the basin include: Pagosa Springs, Colorado, 1,380; Farmington, New Mexico, 23,800; and Shiprock, New Mexico, 2,500, all on the main stem San Juan River; Bayfield, Colorado, 320, and Ignacio, Colorado, 610, on the Los Pinos River; Silverton, Colorado, 820; Durango, Colorado, 10,500; and Aztec, New Mexico, 4,140, on the Animas River; and Cortez, Colorado, 6,800, on McElmo Creek.

The long-term average annual flow of the San Juan River near Bluff, Utah, downstream from the study area is 2,676 cfs. Upstream, near Farmington, New Mexico, the long-term average annual flow is 2,500 cfs. This small difference is explained by irrigation losses and the arid nature of the lower drainage basin.

Water Uses

The New Mexico communities of Shiprock, Farmington, Aztec, and Bloomfield use the San Juan and Animas rivers as sources of public water supply (Table A-16). Farmington, serving a population of 25,000, is the largest system. The San Juan River system serves also as an industrial water supply for mineral ore processing, oil refining, natural gas production and refining, meat packing and by-products processing, sand and gravel washing, electrical power production, and other enterprises.

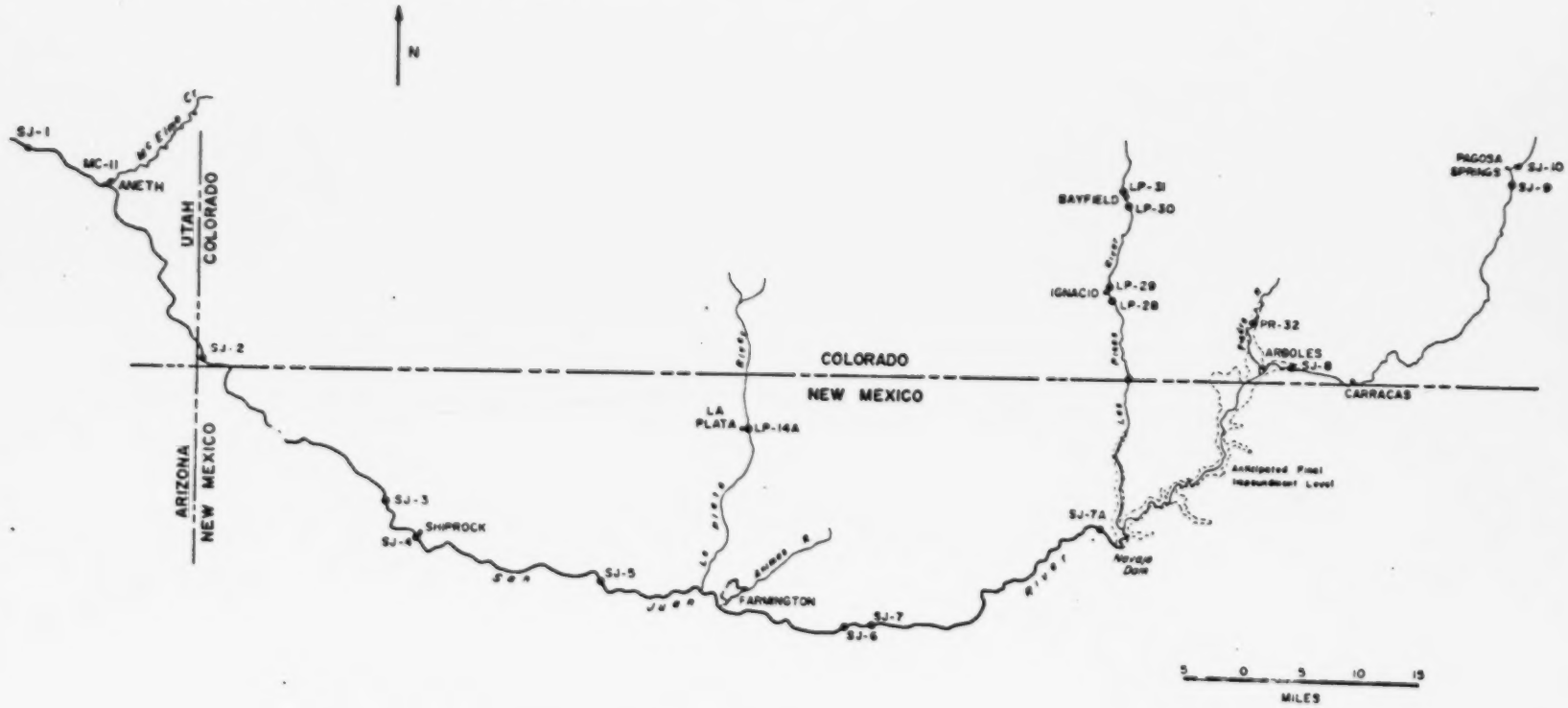
Extensive use is made of the waters for irrigation. Upstream from Bluff, Utah, 200,000 acres are irrigated (Table A-17), and upstream from Shiprock, New Mexico, 118,000 acres are irrigated.

Many of the streams provide both cold- and warm-water fishing and are suitable for swimming and water skiing. The headwater streams are noted as some of the most productive trout waters in the San Juan Basin.

FIG. 5

LOCATION MAP

SAN JUAN RIVER SYSTEM



Waste Sources

Silverton, Colorado, with a sewered population of 900, discnarged untreated sewage to the San Juan River system (Table A-18). All other communities in the basin had conventional secondary treatment facilities or its equivalent. The basin's estimated sewered population of 55,500 discharged 10,000 BOD PE's and 6,000 bacterial PE's. The domestic waste load was divided equally between Colorado and New Mexico.

The 25 industries in the basin employed principally septic tanks, lagoons, or settling ponds for treatment (Table A-19). Of the three states involved, Colorado has 11 industries, New Mexico 13, and Utah one.

Much of the land in the San Juan River basin lies within or adjacent to Indian reservations or national parks. Twenty-one installations in these areas, whose populations range from 100 to 1,600, used either lagoons or septic tanks with accompanying drain fields for waste treatment (Table A-19).

Water Quality - San Juan River

Dissolved Oxygen

Nutrients supplied largely from waste discharges and irrigation return flows stimulated increased algal populations which in turn increased the DO's above saturation. Average DO's were supersaturated at nine of the 15 stations sampled in the San Juan River (Table 18). A minimum DO of 4.0 mg/l was encountered at Station SJ-6; and seven of the 15 stations had minimal values of less tnan 6.0.

Coliform Bacteria

The mean fecal coliform density at all stations was generally less than the criterion recommended by the National Technical Advisory Committee for recreational water use. An exception was Station SJ-5, downstream from the Farmington, New Mexico, waste discharge where the mean density was 2,040 MPN/100 ml (Table 19). Significant maximum fecal coliform densities as high as 17,000 MPN/100 ml occurred at many stations during a rainy period of the study. These maximums were not included in calculation of mean densities.

Salmonella Bacteria

Salmonellae were isolated from gauze swabs placed at Stations SJ-2 and SJ-5 downstream from Shiprock and Farmington, New Mexico; waste outfalls, respectively (Table A-20).

Table 18

SAN JUAN RIVER SYSTEM

Dissolved Oxygen

Designation	River Mile	Approx. elev. ft.	Temp °C	Specific Conduct. µmhos/cm	Tot. Diss. Solids mg/l	Dissolved Oxygen Max. mg/l	Min. mg/l	Avg. mg/l	Sat. mg/l	%Sat.
SJ-10	SJ-362.4	7100	19	-	-	8.3	6.4	7.2	7.29	98.8
SJ-9	SJ-361.0	7000	22	-	-	8.4	5.8	7.6	6.88	110.4
SJ-8	SJ-328.9	6100	24	260	180(1)	9.0	5.7	8.5	6.88	123.5
PR-32	PR- 4.4	6100	22	320	220(1)	8.4	5.9	7.4	7.13	103.8
LP-27	LP- 16.0	6300	22	230	160(1)	7.9	6.4	7.2	7.05	102.1
SJ-7A	SJ-292.0	5700	17	160	110(1)	9.2	8.1	8.6	7.97	107.9
SJ-7	SJ-263.2	5500	23	380	270(1)	8.3	5.0	7.1	7.13	99.6
SJ-6	SJ-262.8	5400	25	570	400(1)	9.0	4.0	7.9	6.89	114.6
AR-15	AR- 1.0	5300	23	570	400(1)	8.5	7.0	7.8	6.94	112.4
LPR-14A	LPR-15.9	5800	22	1420	960(1)	7.2	5.8	6.7	7.15	92.3
SJ-5	SJ-235.2	5100	23	630	410(2)	6.0	5.8	6.9	7.25	95.2
SJ-4	SJ-216.2	4900	24	-	-	9.4	5.6	7.4	7.16	103.4
SJ-3	SJ-213.8	4900	24	880	590(2)	9.6	5.9	7.7	7.13	108.0
SJ-2	SJ-186.0	4600	24	1130	770(2)	7.4	5.5	7.1	7.21	98.5
SJ-1	SJ-158.6	4500	25	1080	740(2)	7.6	6.6	7.2	7.23	99.6

(1) Calculated from specific conductance times 0.7

(2) Calculated from specific conductance by use of factors developed from USGS Water Quality Station Shiprock, N. M.

Table 19

SAN JUAN RIVER SYSTEM

Coliform Bacteria

Station Designation	River Mile	Temp °C	Total Coliforms MPN/100 ml Max.	Total Coliforms MPN/100 ml Mean	Fecal Coliforms MPN/100 ml Max.	Fecal Coliforms MPN/100 ml Mean	Fecal Coliforms as a % of Tot Coliforms
SJ-10	SJ-362.4	19	3,800(1)	190(1)	120(1)	< 10(1)	-
SJ-9	SJ-361.0	22	2,500(1)	460(1)	102(1)	40(1)	7.6
SJ-8	SJ-328.9	24	1,900(1)	< 30(1)	160(1)	< 4(1)	-
PR-32	PR- 4.4	22	17,000	930	1300	< 50	< 5.4
LP-27	LP- 16.0	22	28,000	11,700(1)	8400(1)	550(1)	4.7
SJ-7A	SJ-292.0	17	4,000(1)	200(1)	100(1)	< 2(1)	-
SJ-7	SJ-263.2	23	160,000(1)	250	7000(1)	10	4.0
SJ-6	SJ-262.8	25	> 160,000	4,600	17000	< 90	< 1.9
AR-15	AR- 1.0	25	350,000	6,350	2100	140	2.2
LPR-14A	LPR-15.9	22	5,200	240(1)	63(1)	23(1)	9.5
SJ-5	SJ-235.2	23	160,000	29,700	13,000	2040	6.9
SJ-4	SJ-216.2	24	92,000	4,990	7,900	100	2.1
SJ-3	SJ-213.8	24	92,000	4,820	4,900	190	3.9
SJ-2	SJ-186.0	24	92,000	680	4,900	< 30	< 5.0
SJ-1	SJ-158.6	25	7,900	1,680	500	< 70	< 3.9

(1) MF/100 ml.

Metals

Data on average metals concentrations do not consider the extremely high concentrations that occurred during a rainy period when high suspended solids concentrations occurred in the river (Table 20). Based on dry weather averages, manganese concentrations downstream from Station SJ-8 could interfere with domestic and industrial water uses since concentrations exceeded the 0.05 mg/l U. S. Public Health Service Drinking Water Standard. Total iron concentrations downstream from Station SJ-6 also exceeded the U. S. Public Health Service Drinking Water Standards and could cause water treatment problems for domestic and industrial water users.

Total Dissolved Solids

Total dissolved solids increased by about 6.5 times from upper to lower extremities of the reach studied. From a point downstream from the Navajo Reservoir (SJ-7A) to Aneth, Utah (SJ-1), the TDS increased from 160 to 740 mg/l. This increase changed the value of the water for irrigation purposes from one of virtually no hazard to one detrimental to sensitive crops (Table 21). A TDS concentration of 960 mg/l occurred in the La Plata River, also adversely affecting the water's value for irrigation. These concentrations would not be expected to damage fish and other aquatic life.

Water Quality - Animas River

The headwaters of the Animas River and its tributaries, Mineral and Cement creeks, drain an area containing sulfide minerals (Figure 6). These minerals are oxidized when exposed to air and yield waters of high metal concentrations and low pH. Extensive mining activities have increased the surface exposure of these sulfide deposits and have resulted in stream degradation in the upper Animas Basin.

Dissolved Oxygen

Minimum DO's encountered during the survey exceeded 5.5 mg/l (Table 22). All stations in the basin exceeded 88 percent of saturation at the times that samples were collected. Most stations exhibited supersaturation of DO in at least one sample.

Coliform Bacteria

Upstream from Durango, Colorado, fecal coliform densities were affected by toxic metals and low pH values (Table 23). At Station AR-21 downstream from the raw waste discharges from Silverton, Colorado, for example, the maximum densities of total and fecal

Table 30

SAN JUAN RIVER SYSTEM

Metals

Station Designation	River Mile	Aluminum mg/l		Chromium mg/l		Copper mg/l		Iron mg/l		Manganese mg/l		Zinc mg/l	
		Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg.	Max.	Avg
SJ-8	328.9	31.0	< 1.2	0.0	0.0	0.04	< 0.02	16.5	< 0.29	1.4	< 0.04	0.40	< 0.10
PR-32	4.4(3)	13.5	< 0.8	0.0	0.0	0.02	< 0.01	3.6	0.44	0.24	0.06	0.17	< 0.08
LP-27	16.0(3)	3.3	2.0	0.0	0.0	0.02	< 0.01	1.81	1.08	0.15	0.12	0.14	< 0 06
SJ-6	262.8	1770.0	< 2.3	1.1	0.0	0.04	< 0.01	85.0	1.11	4.1	0.12	4.4	0.10
AR-15	1.0(3)	2.3	< 1.0	0.0	0.0	0.02	< 0.02	1.14	0.43	0.16	0.10	0.08	< 0 05
LPR-14A	15.9(3)	54.0	1.1	< 0.1	0.0	0.2	< 0.01	4.39	0.14	0.43	0.08	0.2	< 0 06
SJ-5	235.2	550.0	1.8	0.3	0.0	0.02	< 0.01	2.15	0.70	3.5	0.12	1.3	< 0.04
SJ-3	213.8	275	1.5	0.2	0.0	0.03	< 0.01	4.82	0.47	4.1	0.08	0.8	< 0.04
SJ-2	186.0	480	< 1.0	0.3	0.0	0.02	< 0.01	1.39	0.37	1.7	< 0.05	1.3	< 0 04
SJ-1	158.6	3.5	< 1.5	0.0	0.0	0.02	< 0.01	0.98	0.51	0.18	0.06	0.04	< 0.04
Saturation conc.)(1) (25°C., pH = 8.3)			0.135		-		0.06		0.0001		0.28		0.001

(1) Estimated from charts in the following reference:

Stumm, W., "Chemistry of Natural Waters in Relation to Water Quality." Symposium on Environmental Measurements, U. S. Department of Health, Education, and Welfare, Publication 999-WP-15. July. 1962.

(2) Calculated on the basis of 160 mg/l chlorides

(3) Tributary mileage upstream from confluence with San Juan River

Table 21

SAN JUAN RIVER SYSTEM

Total Dissolved Solids

Station Designation	River Mile	Specific Conductance µmhos/cm	Total Dissolved Solids mg/l	Sodium mg/l	Sodium Adsorption Ratio
SJ-8	SJ-328.9	260	180(1)	-	-
PR-32	PR- 4.4	320	220(1)	-	-
LP-27	LP- 16.0	230	160(1)	-	-
SJ-7A	SJ-292.0	160	110(1)	-	-
SJ-7	SJ-263.2	380	270(1)	-	-
SJ-6	SJ-262.8	570	400(1)	-	-
AR-15	AR- 1.0	570	400(1)	-	-
LFR-14A	LFR-15.9	1370	960(1)	-	-
SJ-5	SJ-235.2	630	410(2)	40	1.31
SJ-3	SJ-213.8	880	590(2)	90	2.39
SJ-2	SJ-186.0	1130	770(2)	130	3.35
SJ-1	SJ-158.6	1080	740(2)	120	3.17

(1) Estimated on basis of 0.7 times specific conductance.

(2) Calculated from specific conductance by use of factors developed from USGS station at Shiprock, New Mexico

FIG. 6

LOCATION MAP

ANIMAS RIVER

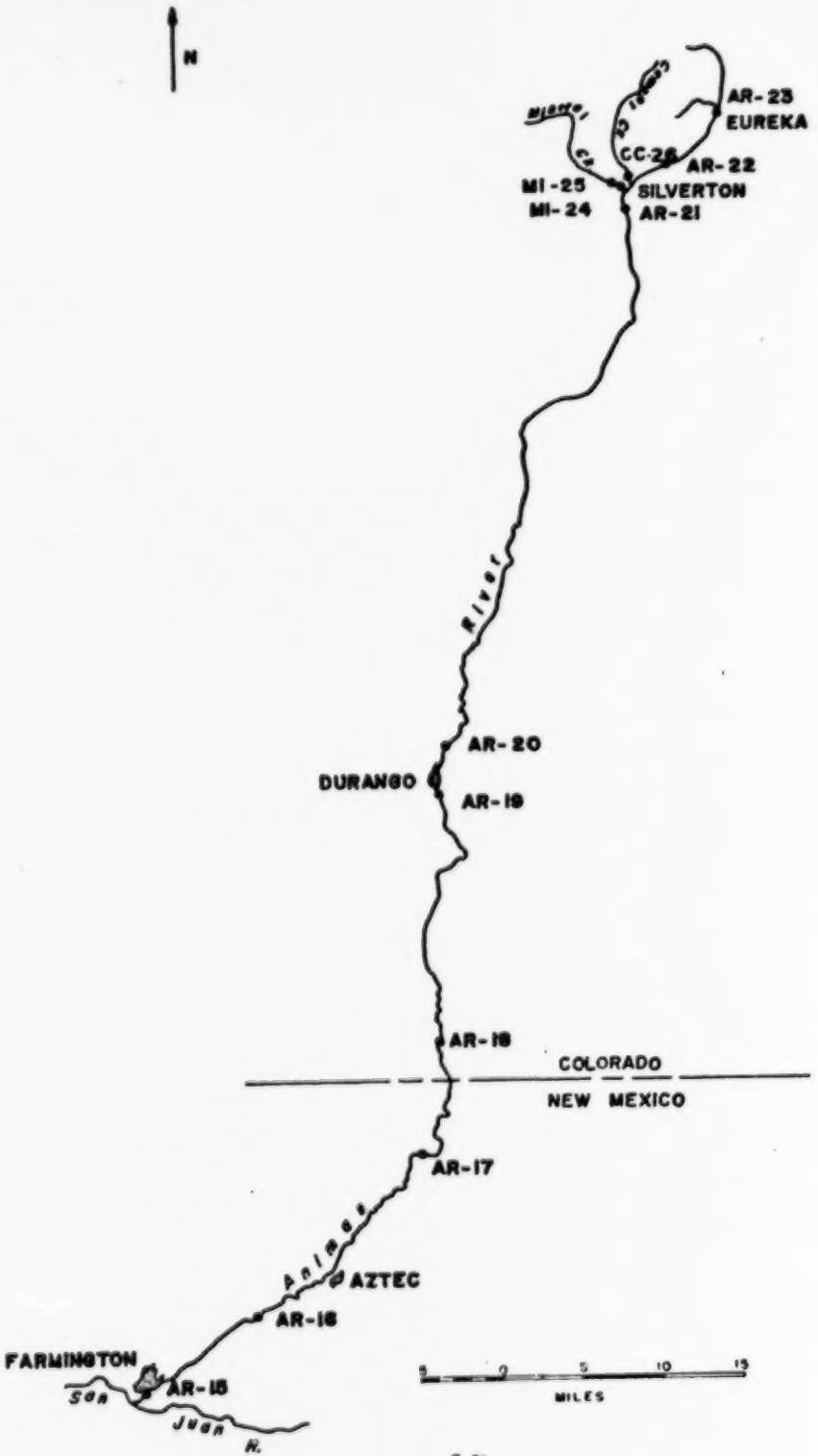


TABLE 22

ANIMAS RIVER SYSTEM

Dissolved Oxygen

Station Designation	River Mile	Approx. Elev. ft.	Temp. °C	Spec. Conduc. µmos/cm	Tot. (1) Diss. Solids mg/l	Dissolved Oxygen Max. mg/l	Min. mg/l	Avg. mg/l	Sat. mg/l	% Sat.
AR-23	AR-115.1	10,000	13	250	180	7.9	6.2	6.7	7.27	92.2
AR-22	AR-112.2	9,500	13	170	120	7.7	6.2	6.6	7.41	89.1
CC-26	AR-107.4 - 0.5	9,400	14	740	520	7.4	6.1	6.7	7.28	92.0
MI-25	AR-107.4 - 0.5	9,300	13	220	150	8.1	6.1	6.8	7.47	91.0
MI-24	AR-107.4 - 0.2	9,300	13	220	150	8.7	5.7	6.8	7.47	91.0
AR-21	AR-105.9	9,300	15	330	230	8.5	5.6	6.4	7.15	89.5
AR-20	AR- 59.8	6,500	18	420	290	8.1	5.8	6.7	7.58	88.4
AR-19	AR- 55.8	6,400	18	430	300	8.4	5.8	7.0	7.62	92.0
AR-18	AR- 38.2	6,000	20	420	300	8.1	5.5	6.8	7.43	91.5
AR-17	AR- 28.0	6,000	21	-	-	7.5	6.0	6.8	7.28	93.4
AR-16	AR- 10.7	5,500	23	540	380	8.4	5.6	7.0	7.15	97.9
AR-15	AR- 1.0	5,300	25	570	400	8.5	7.0	7.8	6.94	112.4

(1) Calculated from equation: 0.7 (specific conductance)

Table 23

ANIMAS RIVER SYSTEM

Coliform Bacteria

Station Designation	River Mile	Temp °C	Total Coliforms MPN/100 ml Max.	Total Coliforms MPN/100 ml Mean	Fecal Coliforms MPN/100 ml Max.	Fecal Coliforms MPN/100 ml Mean	Fecal Coliforms as a % of Tot Coliforms
AR-23	AR-115.1	13	< 2(1)	< 2(1)	< 2(1)	< 2(1)	-
AR-22	AR-111.2	13	120(1)	< 5(1)	7(1)	< 2	-
CC-26	AR-107.1 - 0.5	14	24(1)	< 4(1)	< 2(1)	< 2(1)	-
MI-25	AR-107.4 - 0.5	13	14(1)	< 2(1)	< 2(1)	< 2(1)	-
MI-24	AR-107.4 - 0.2	13	23(1)	< 4(1)	< 3(1)	< 2(1)	-
AR-21	AR-105.9	15	60(1)	<12(1)	< 2(1)	< 2(1)	-
AR-20	AR- 59.8	18	360(1)	130(1)	30(1)	< 6(1)	< 4.7
AR-19	AR- 55.8	18	350,000	65,400	70,000	9,800	15.0
AR-18	AR- 38.2	20	92,000	16,600	9,400	1,480	8.9
AR-17	AR- 28.0	21	24,000	9,180	2,300	630	6.8
AR-16	AR- 10.7	23	35,000	7,940	4,600	540	6.8
AR-15	AR- 1.0	25	350,000	6,350	2,100	140	2.2

(1) MF/100 ml

coliforms were only 60 and less than 2 MF/100 ml, respectively. Much higher densities would have occurred were toxic constituents not present in the water.

Downstream from Durango, at Station AR-19, the mean fecal coliform density was 9,800 MPN/100 ml, five times the recommended criterion for recreational usage. The maximum fecal coliform density at this station was 70,000 MPN/100 ml. Natural die-away reduced the density to 1,480 MPN/100 ml, 17.6 miles downstream at Station AR-18.

Salmonella Bacteria

Of four areas examined, pathogenic Salmonellae were isolated only at Station AR-19 downstream from Durango, Colorado (Table A-21).

Metals

The upstream reaches of the Animas River basin had toxic concentrations of copper, manganese, iron, zinc, and cyanide that were adversely affecting aquatic life (Table 24). The cyanide concentrations were especially serious because the communities of Durango, Colorado; Aztec, New Mexico; and Farmington, New Mexico, depend upon this water as a source of public supply. Upstream from Durango, the average cyanide concentration of 0.7 mg/l was 3-1/2 times the U. S. Public Health Service Drinking Water Standards. Iron and manganese concentrations consistently exceeded the U. S. Public Health Service Drinking Water Standards. The highest average concentrations were 0.92 mg/l iron, and 2.1 mg/l manganese at Station AR-21 downstream from Silverton, Colorado.

Total Dissolved Solids

The total dissolved solids concentration increased from 120 mg/l upstream from Silverton, Colorado, to 400 mg/l near Farmington, New Mexico, and should not seriously affect water usage (Table 22).

Water Quality - Los Pinos River

Dissolved oxygen concentrations in the Los Pinos River averaged greater than 7.0 mg/l (Table 25). Although supersaturation of DO was observed at all stations, the small diurnal variation would not create biological problems. The mean fecal coliform densities at all stations sampled were less than the maximum criterion recommended for recreational water use.

Table 24

ANIMAS RIVER SYSTEM

Metals

Station Designation	River Mile	Total Sus. Solids mg/l Max.	Avg.	pH Units	Alk. mg/l $CaCO_3$	Acidity mg/l $CaCO_3$	Aluminum mg/l Max.	Avg.	Arsenic mg/l Max.	Avg.	Copper mg/l Max.	Avg.	Iron mg/l Max.	Avg.	Manganese mg/l Max.	Avg.	Zinc mg/l Max.	Avg.	Cyanide mg/l Max.	Avg.
AR-23	AR-115.1	15	< 4	7.0	15	-	< 2.0	<0.9	-	-	0.16	0.06	0.24	< 0.19	1.1	1.0	0.9	0.63	-	-
AR-22	AR-111.2	10	< 3	7.0	25	-	< 2.0	<1.2	-	-	0.03	<0.02	0.52	< 0.28	0.89	0.56	0.70	0.4[illegible]	-	-
CC-26	AR-107.1-0.5	31	16	5.0	0	34.0	3.5	2.8	0.003	0.000	0.10	0.09	6.95	6.40	2.3	2.7	2.1	1.9	1.0	0.9
MI-25	AR-106.4-0.5	12	< 6	6.9	14	-	< 2.0	<1.4	0	0	0.06	0.04	2.15	1.62	0.23	0.20	0.26	0.2[illegible]	1.[illegible]	0.7
AR-21	AR- 105.9	11	4	6.5	6	3.8	2.4	<1.3	0.002	0.000	0.25	0.13	1.61	0.92	3.7	2.1	1.1	0.69	2.7	1.4
AR-20	AR- 59.8	14	< 6	7.4	98	-	0.8	<0.5	0	0	0.02	<0.01	1.10	0.53	0.20	0.15	0.20	0.18	1.3	0.7
AR-19	AR- 55.8	114	25	7.9	99	-	2.3	<1.0	-	-	0.04	<0.02	1.72	0.66	0.21	0.14	0.20	0.17	-	-
AR-18	AR- 38.2	68	29	8.2	105	-	3.3	<1.0	0	0	0.03	<0.01	1.27	0.63	0.21	0.13	0.20	0.14	1.7	<0.[illegible]
AR-15	AR- 1.0	163	50	8.5	128	-	2.3	<1.0	0	0	0.02	<0.02	1.14	0.43	0.16	0.10	0.08	<0.05	1.[illegible]	0.[illegible]
Saturation concentration (25°C, pH = 8.3)(1)								0.68				0.26		0.0002		0.03				0.[illegible]

(1) Estimated from charts in following reference:

Stumm, W., "Chemistry of Natural Waters in Relation to Water Quality," Symposium on Environmental Measurements, U. S. Department of Health, Education, and Welfare, publication 999-WP-15, July 1964.

Table 65

LOS PINOS RIVER

Data Summary

Station Designation	River Mile	Flow cfs	Temp °C	pH Units	Alk. mg/l $CaCO_3$	Spec. Cond. µmhos/cm	Chloride mg/l	Turbidity Units	Suspended Solids Total mg/l	Suspended Solids Volatile mg/l	BOD mg/l	D. O. mg/l	Total /100 ml	Fecal /100 ml	% of Total Coliforms
Los Pinos River															
USGS Gage	LP-43.4	693													
LP-31	LP-33.4		10	-	-	-	-	-	-	-	-	7.9	210	< 1	-
LP-29	LP-25.2		21	-	-	-	-	-	-	-	-	7.5	1,000	< 40	< 1.0
LP-27	LP-16.0		22	8.1	100	230	-	14	6	< 1	2.9	7.2	11,700	450	3.7
USGS Gage	LP-10.0	173													

Water Quality - McElmo Creek

The flow in McElmo Creek upstream from Cortez, Colorado, was composed principally of irrigation return waters imported from the Dolores River Basin. Downstream from Cortez, the flow was augmented by the city's sewage discharges. The long-term average annual flow near the Colorado-Utah state line is 41 cfs (Figure 7).

Dissolved Oxygen

Dissolved oxygen concentrations were satisfactory at all stations sampled (Table 26). Minimum DO's exceeded 5.5 mg/l.

Coliform Bacteria

The discharge of primary treated sewage from Cortez, Colorado, increased the mean fecal coliform density to 30,100 MPN/100 ml with a maximum density of 220,000 MPN/100 ml (Table 27). The mean density was 15 times that recommended by the National Technical Advisory Committee as a criterion for recreational waters. Ten miles downstream from Cortez the mean fecal coliform density was 5,570 MPN/100 ml. Thirty-five miles farther downstream, near the mouth of McElmo Creek. the mean fecal coliform density was reduced to a level near the recommended criterion. The maximum density observed remained at 13,000 MPN/100 ml, indicating a hazard for recreational usage at all points downstream from Cortez, Colorado. Pathogenic Salmonellae were isolated near the mouth of McElmo Creek (Table A-22).

Total Dissolved Solids

Total dissolved solids concentrations exceeded 1,800 mg/l and 2,600 mg/l at MC-11 and MC-13, the two stations examined. These high TDS concentrations made McElmo Creek undesirable for livestock watering. Use of the water for irrigation might cause adverse effects on many crops. About 1,000 acres are irrigated in this basin upstream from the Colorado-Utah state line.

FIG. 7

LOCATION MAP

McELMO CREEK

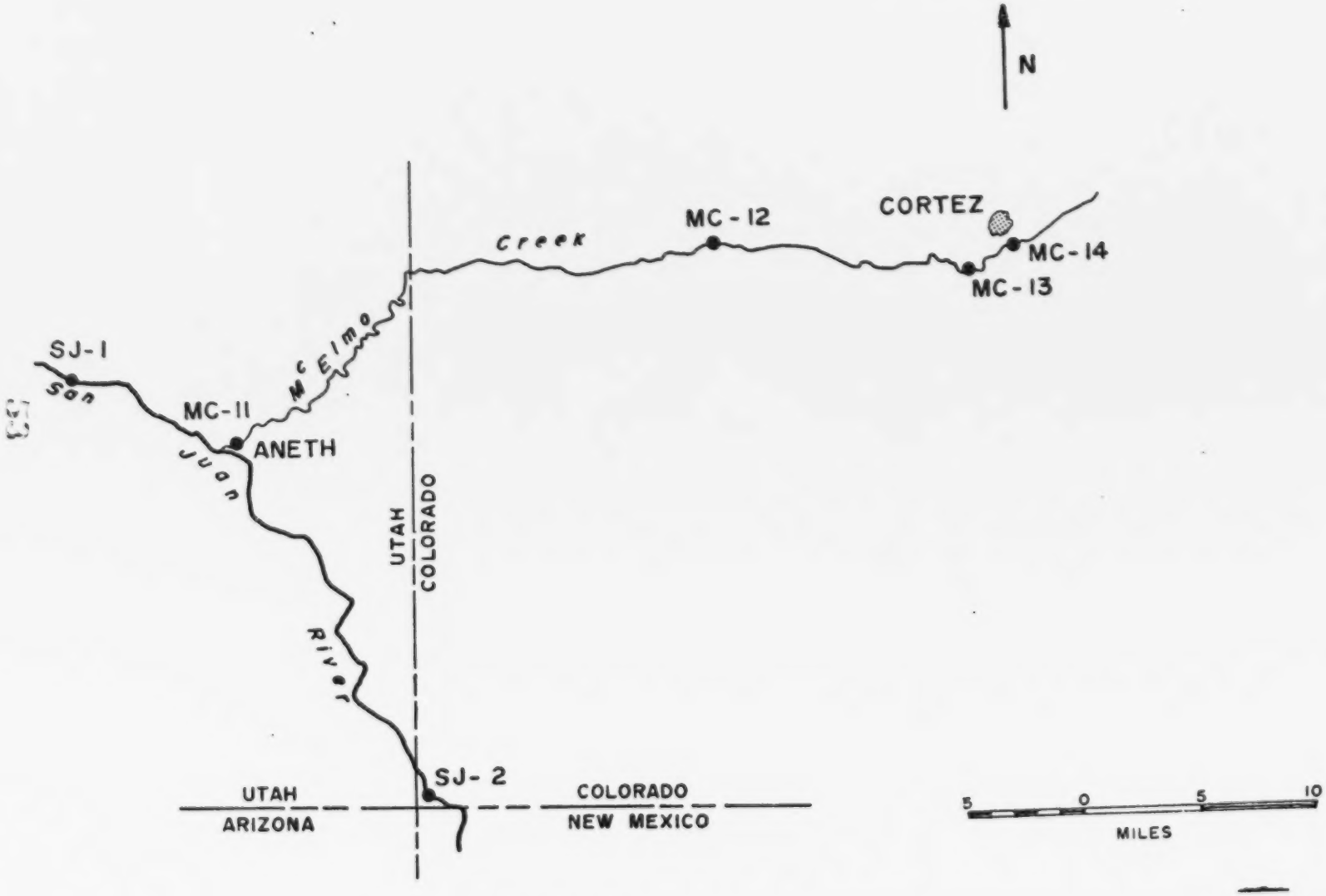


Table 26

McELMO CREEK

Dissolved Oxygen

Station		Approx. Elev. ft.	Temp. °C	Spec. Conduc. µmhos/cm	Tot. (1) Diss. Solids mg/l	Dissolved Oxygen				
Designation	River Mile					Max. mg/l	Min. mg/l	Avg. mg/l	Sat. mg/l	% Sat.
MC-14	MC-50.0	[illegible],050	24	-	-	-	-	7.4	6.77	109.3
MC-13	MC-45.4	5,900	24	3,770	2,640	7.8	5.8	6.7	6.80	98.5
MC-12	MC-35.5	5,350	21	-	-	-	-	6.9	7.33	94.1
MC-11	MC-0.1	4,600	25	2,410	1,850	7.4	6.2	7.0	7.00	100.0

(1) Calculated from specific conductance.

Table 27

McELMO CREEK

Coliform Bacteria

Station Designation	River Mile	Temp °C	Total Coliforms MPN/100 ml Max.	Total Coliforms MPN/100 ml Mean	Fecal Coliforms MPN/100 ml Max.	Fecal Coliforms MPN/100 ml Mean	Fecal Coliforms as a % of Tot Coliforms
MC-14	MC- 50.0	24	2,600	450	110	< 20	< 4.4
MC-13	MC- 45.4	24	1,600,000	368,500	220,000	30,100	8.2
MC-12	MC- 35.5	21	240,000	65,500	49,000	5,570	8.5
MC-11	MC- 0.1	25	92,000	16,300	13,000	1,040	6.4

APPENDIX

Table A-1

COLORADO RIVER: RIFLE, COLO.-MOAB, UTAH

Estimated Acres Under Irrigation

USGS Gaging Station Location	River Mile	Estimated Acres Above Station Irrigated	Estimated Acres Between Station Irrigated
Near Glenwood Springs, Col.	C-1199.5	70,000 (1)	
Near Cameo, Col.	C-1129	160,000	90,000
Plateau Creek	C-1123.3	25,000	
Gunnison River	C-1101.8	233,000	
Near Col. - Utah line	C-1068.2	518,000 (2)	358,000
Near Cisco, Utah	C-1023	(3)	-

(1)Upstream from study reach

(2)Estimated on basis of land area and field inspection of irrigation practices

(3)Small additional area irrigated below state line

Table A-2

COLORADO RIVER: RIFLE, COLO.-MOAB, UTAH

Sources of Municipal Wastes

Location	Est. Pop. Served	Treatment	Estimated lbs Discharged BOD$_5$	Sus. Sol.	Bacterial
Colorado					
Rifle[1]	3,000	Aerated Lagoons	0	0	0
Grand Valley San. Dist.	300	Act. Sludge Cl_2	30	30	3
Collbran	300	Primary	200	150	150
Mesa	100	Primary	67	50	50
Palisade	1,200	Lagoons	120	120	36
Clifton San.Dist.					
No. 1	1,000	Lagoons	100	100	30
No. 2	1,200	None[2]	1200	1200	1200
Grand Junction					
So. Side Plt.	3,500	H.R.Tr.Fil.	700	700	440
West Side Plt.	19,500	H.R.Tr.Fil.	3900	3900	2440
5th St. Outfl.	100	None	100	100	100
Fruita	1,500	Lagoons	150	150	45
Gateway	200	Primary	133	100	100
Silt[3]	450	Primary	150	225	225
Utah					
Moab[4]	4,200	Primary	2800	2100	2100
Totals	36,550		9650	8925	6919

(1) Use evaporation lagoons with no discharge.
(2) Presently have a lagoon.
(3) New plant under construction.
(4) Secondary treatment installed in 1968.

Table A-3

COLORADO RIVER: RIFLE, COLO.-MOAB, UTAH

Sources of Industrial Wastes

Installation	Location	Principal Products	Process Waste Treatment
Colorado			
Rifle Packing Co.	Rifle	Dressed Meat	Septic tank & drainfield
Union Carbide Corp.-Rifle Plant	Rifle	Uranium Refining	Tailings Ponds
Grand Valley Rendering Co.	Grand Valley	Grease	None
Climax Uranium Co.	Grand Junction	Uranium Refining	Tailings Ponds
Western Meat Packers, Inc.	Grand Junction	Dressed Meat	None
American Gilsonite Corp.	Fruita	Gasoline, Hydrocarbon Products	Grease Removal, Lagoon
Brach Packing Co.	Fruita	Dressed Meat	Lagoons
Utah			
Atlas Minerals	Moab	Uranium Refining	Chemical Treatment, settling lagoon
Texas Gulf Sulfur	Moab	Potash	Evaporation lagoon
Micro Copper	Moab	Powdered Copper	Tailings Ponds

Table A-4

COLORADO RIVER: RIFLE, COLO.-MOAB, UTAH

Institutional Wastes

Installation	No. of Employees or pop.	Treatment provided	Estimated PE Discharged		
			BOD_5	Sus.Sol.	Bacterial
U.S. Bureau of Mines-Anvil Points	200	septic tank	123	100	100
Collbran Job Corps Camp	135	lagoon	14	14	1
Collbran Job Corps Conservation Center	100	lagoon	10	10	1
U.S. Atomic Energy Comm.-Grand Junction	300	septic tank, lagoon	20	15	2
Totals	735		177	139	104

Table A-5

COLORADO RIVER: RIFLE, COLO.-MOAB, UTAH

Salmonella Isolations

Station	Probable Source	Species Identified
C-9	Unintercepted Grand Junction sewage	S. anatum S. siegburg S. typhimurium
C-10	Grand Junction sewage	S. newport S. infantis
C-12	Grand Junction and Fruita sewage	S. montevideo S. anatum S. sandiego
C-18	Moab sewage	S. typhimurium

Table A-6

COLORADO RIVER BASIN STUDIES

Reports of Salmonella Isolations from the States

The seven most commonly reported serotypes from human sources during July 1966 were:

Rank	Serotype	Number	Percent	Rank Preceding Month
1	S. typhi-murium and S. typhi-murium var. copenhagen	464	28.5	1
2	S. heidelberg	163	10.0	2
3	S. enteritidis	111	6.8	6
4	S. newport	96	5.9	7
5	S. infantis	90	5.5	5
6	S. saint-paul	70	4.3	Not Listed
7	S. thompson	59	3.6	Not Listed
	TOTAL	1,053	64.6	
	TOTAL (all serotypes)	1,630		

Source: Salmonella Surveillance Committee Report
August 1966.

Table A-6
(contd.)

COLORADO RIVER BASIN STUDIES

Reports of Salmonella Isolations from the States

The seven most commonly reported serotypes from human sources during August 1966 were:

Rank	Serotype	Number	Percent	Rank Preceding Month
1	S. typhi-murium and S. typhi-murium var. copenhagen	778	32.3	1
2	S. heidelberg	194	8.1	2
3	S. newport	186	7.7	4
4	S. infantis	125	5.2	5
5	S. enteritidis	107	4.4	3
6	S. thompson	98	4.1	7
7	S. saint-paul	96	4.0	6
	TOTAL	1,584	65.8	
	TOTAL (all serotypes)	2,408		

Source: Salmonella Surveillance Committee Report
September 1966.

Table A-7

PRICE RIVER SYSTEM

Estimated Acreage Irrigated

USGS Gaging Station Location	River Mile	Estimated Acres Above Station Irrigated	Estimated Acres Between Station Irrigated
near Scofield, Utah	P-110.5	(a)	
near Heiner, Utah	P-103.6	(a)	
near Woodside, Utah	P-20	18,000	17,000

(a) small amount of irrigation above station

Table A-8

PRICE RIVER SYSTEM

Sources of Municipal Wastes

Location	Est. Pop. Served	Treatment	Estimated PE Discharged		
			BOD_5	Sus.Sol.	Bacterial
Castle Gate	300	Primary	200	150	150
Helper	2500	Primary	1670	1250	1250
Kenilworth	400	Primary	270	200	200
Price	6800	None	6800	6800	6800
Wellington	1000	None	1000	1000	1000
Dragerton	2500	Tr. Ftr., Cl_2	375	375	25
Columbia	400	Primary	270	200	200
Total	13,900		10,585	9975	9625

Table A-9

PRICE RIVER SYSTEM

Sources of Industrial Wastes

Installation	Location	Principal Products	Process Waste Treatment
Mariana Air Products	Wellington	Dry Ice	None
Carbon Emery By-Products	Price	Meat Meal	None
Independent Coal & Coke Co.	Castle Gate	Coal Washing	Settling lagoon
Jeanselmes Mkt. & Slaughterhse.	Price	Meat	Septic tank
U.S. Fuel Co.	Hiawatha	Coal Washing	Lagoon
Wellington Coal Cleaning	Wellington	Coal Washing	Evaporation lagoons

Table A-10

PRICE RIVER SYSTEM

SALMONELLA ISOLATIONS

Station	Probable Source	Species Identified
P-19	Unknown	S. sandiego
P-23	Castle Gate and Helper, Utah sewage	S. schwarzengrund
P-25	Price, Utah sewage	S. heidelberg S. schwarzengrund

Table A-11

GUNNISON RIVER SYSTEM

Estimated Acreage Irrigated

USGS Gaging Station Location	River Mile	Estimated Acres Above Station Irrigated	Estimated Acres Between Stations Irrigated
Near Gunnison, Colorado	G-149.5	22,000	22,000
Ohio Creek nr. Baldwin	G-150	3,850	
Below Blue Mesa Dam	G-119.5	56,000	34,000
Below Gunnison Tunnel	G-97.5	63,000	7,000
North Fork Gunnison near Somerset	G-72.3	3,000	
Near Lazear	G-72.25	150,000(1)	87,000
Uncompahgre River at Delta	G-54.5	90,000	
Near Grand Junction	G-14.7	233,000	83,000
Uncompahgre River			
Near Ridgeway	U-51.5		
At Colona	U-40.0	19,000	19,000
At Delta	U-1.2	90,000	71,000

Notes:

(1) Includes some irrigation in the Uncompahgre Basin through diversion from Gunnison Basin

Table A-12

GUNNISON RIVER SYSTEM

Sources of Municipal Wastes

Location	Est. Pop. Served	Treatment Provided	Estimated PE Discharged		
			BOD_5	Sus. Sol.	Bacterial
Gunnison River					
Crested Butte & San. Dist.	500	Lagoon	50	50	5
Gunnison	6300	H.R. Trick. Fltr.	1260	1260	790
North Fork Gunnison					
Paonia	1000	Lagoon, Cl_2(1)	100	100	0
Hotchkiss	600	none	600	600	600
Uncompahgre River					
Ouray	800	none	800	800	800
Ridgeway	300	none	300	300	300
Montrose	7500	H.R. Tr. Ftr., Cl_2	1500	1500	75
Olathe	800	none	800	800	800
Delta	4000	Lagoon	400	400	40
Totals	21,800		5810	5810	3410

Note:

(1) Discharged raw sewage during 1966 survey

Table A-13

GUNNISON RIVER SYSTEM

Sources of Industrial Wastes

Installation	Location	Principal Products	Process Waste Treatment
Gunnison River			
Western Tanning & Manufac. Co.	Delta	Leather	Evaporation lagoon
Burkey Lumber Co.	Delta	Lumber	Log pond
Holly Sugar Co.	Delta	Sugar	None
Surface Creek Creamery Assn.	Delta	Butter	Septic tank
North Fork Gunnison			
none			
Uncompahgre River			
Camp Bird Colo., Inc.	Camp Bird	Mining, ore processing	Tailings ponds
Idarado Mine	Telluride	Mining	Tailings ponds
Calloway Packing, Inc.	Colona	Dressed Beef	None
Western Slope Hide & Rend. Co.	Montrose	Grease	None
Colorado Lumber Prod. Co.	Montrose	Lumber	Log ponds
Skyland Food Corp.	Delta	Canned Fruits & Vegetables	City sever
Speas Vinegar Co.	Delta	Vinegar	City sever

Table A-14

GUNNISON RIVER SYSTEM

Sources of Institutional Wastes

Installation	No. of Employees	Treatment Provided	Estimated PE Discharged		
			BOD_5	Sus. Sol.	Bacterial
Gunnison River					
Blue Mesa Power Plant	75	Septic tank, undergrd. disposal	0	0	0
Blue Mesa Field Office	10	Septic tank, undergrd. disposal	0	0	0
North Fork Gunnison					
none					
Uncompahgre River					
Silver Jack Field Sta.	15	Septic tank	10	10	8
Morrow Point Field Sta.	200	Septic tank, undergrd. disposal	0	0	0
CRSP Power Operations Center	125	none	125	125	125
Total	425		135	135	133

Table A-15

GUNNISON RIVER SYSTEM

Salmonella Isolations

Station	Probable Source	Species Identified
G-10	Paonia & Hotchkiss, Colo. on N.F. Gunnison River	S. oranienburg S. blockley
G-12	Delta, Colorado sewage	S. typhimurium S. Oranienburg

Table A-16

SAN JUAN RIVER SYSTEM

Water Supplies

Community	Population Served	Source of Supply
Colorado		
none		
New Mexico		
Shiprock	2,500	San Juan River
Farmington	25,000	Animas River
Aztec	4,137	Animas River
Bloomfield	1,000	San Juan River
Blanco		San Juan River
Village of Turley		San Juan River
Utah		
none		

Table A-17

SAN JUAN RIVER SYSTEM

Estimated Acreage Irrigated

USGS Gaging Station Location	River Mile	Estimated Acres Above Station Irrigated	Estimated Acres Between Station Irrigated
At Pagosa Springs, Colo.	SJ-361.8	-	-
Near Carracas, Colo.	SJ-325.9	11,000	-
Piedra River near Arboles	SJ-318.7(1)	2,800	-
Los Pinos near La Boca, Colo.	SJ-295.9(1)	33,000	-
Near Archuleta, N. M.	SJ-284.8	47,000	36,000
Animas River at Farmington	SJ-249.0(1)	30,000	-
At Farmington, N. M.	SJ-248.2	86,000	39,000
La Plata River near Farmington	SJ-245.6(1)	24,000	
At Shiprock, N. M.	SJ-213.8	118,000	32,000
Near Bluff, Utah	SJ-114	200,000	82,000
Los Pinos River			
Near Bayfield, Colo.		-	
Near La Boca, Colo.		33,000	

(1) San Juan River mile where t utary enters.

Table A-18

SAN JUAN RIVER SYSTEM

Sources of Municipal Wastes

Community	Est. Pop. Served	Treatment	Estimated PE Discharged BOD_5	Sus.Sol.	Bacterial
Colorado					
Pagosa Springs	1,500	Lagoon	150	150	15
Ignacio	900	Lagoon	90	90	9
Bayfield	300	Lagoon	30	30	3
Silverton	900	None	900	900	900
Durango	9,500	H.R. Tr. Ftr.	1900	1900	1190
Cortez	8,000	Lagoon	800	800	80
Total	21,100		3870	3870	2197
New Mexico					
Bloomfield	1,900	H.R. Tr. Ftr., Lagoon	40	40	2
Farmington	25,000	H.R. Tr. Ftr.	5000	5000	3125
Shiprock	2,500	Lagoon	250	250	25
Aztec	5,000	H.R. Tr.	1000	1000	625
	34,400		6290	6290	3777
Utah					
None	0		0	0	0
Totals	55,500		10,160	10,160	5974

Table A-19

SAN JUAN RIVER SYSTEM

Sources of Wastes

Installation	Location	Principal Products	Process Waste Treatment
Colorado	INDUSTRIAL		
Standard Metals	Silverton	Zinc, lead, silver	Tailings ponds
Whiteman Lumber Co.	Durango	Lumber	Settling ponds
San Juan Lumber Co.	Pagosa Spgs	Lumber	Log pond
Montezuma Plywood	Cortez	Plywood	Lagoons
EPNG-Ignacio Plany	Ignacio	Gas	Dry wash
Northside Packing Co.	Cortez	Meat	Septic tank, tile field
Burnett Construction	Durango	Gravel	Sedimentation
Vanadium Corp. of America	Durango	Uranium	Tailings piles
Basin Meat Packing	Durango	Meat	Septic tank
Cortez Tallow	Cortez	Grease	Lagoon
Colorado Carbonies	-	Dry Ice	-
New Mexico			
Plateau Refinery	Farmington	Gasoline	Evaporation lagoon
Asphalt Paving Sand & Gravel	Farmington	Gravel Washing	-
Beeline Refining Co.	Farmington	Gasoline	Evaporation lagoon
Four Corners Carbon Refinery	Farmington	Carbon Black	-
Allison & Haney Const. Co.	Shiprock	Washed Sand	Sedimentation pond

Table A-22

McELMO CREEK

Salmonella Isolations

Station	Probable Source	Species Identified
MC-11	Cortez, Colo. sewage	S. denver S. newport
MC-13	Cortez, Colo. sewage	Swab not recovered.